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Types of Wildlife Trees and Coarse Woody Debris Required by Wildlife of North-Central British Columbia

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Types of Wildlife Trees and Coarse Woody Debris Required by Wildlife of North-Central British Columbia

Dagmar G. Keisker

BRITISH COLUMBIA

Ministry of Forests Research Program

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ABSTRACT

If wildlife diversity is to be maintained in managed forests, the habitat needs of all wildlife species must be met. This report provides some of the necessary information by describing the habitat requirements of 133 vertebrate species of north-central British Columbia in relation to two special habitat elements: Wildlife Trees and Coarse Woody Debris. To make it easier for habitat managers to apply this information, requirements were condensed into a series of Habitat Summary Tables. The tables, which are based mainly on published research reviewed up to 1995, describe in detail the varieties of Wildlife Trees and Coarse Woody Debris that are required by wildlife.

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User's Guide to the Habitat Summary Tables

INTRODUCTION

Wildlife Trees and Coarse Woody Debris

In recent years, forest managers have become increasingly aware of the role both of trees with special characteristics ("wildlife trees") and of fallen woody material ("coarse woody debris") in maintaining biodiversity. These forest elements, which often result from damage or disease, provide critical wildlife habitat that will not necessarily be available in managed stands unless special measures are taken to ensure its presence.

In British Columbia, several initiatives have been taken to provide Wildlife Trees (WTs) and Coarse Woody Debris (CWD) in managed stands. The Wildlife Tree Committee, a joint undertaking of the Ministry of Forests, Ministry of Environment, Lands and Parks, Workers' Compensation Board, and several other groups, was formed in 1985 to find ways to maintain WTs without compromising worker safety. This partnership has resulted in a training program in which forest workers have learned to conserve WTs where possible, to recognize dangerous trees, and to make appropriate safety decisions (Wildlife Tree Committee of British Columbia 1997). The *Forest Practices Code of British Columbia Act* and its associated regulations, which came into effect in 1995, recognized the importance of WTs and CWD by requiring that forest development plans set objectives for their retention. The Biodiversity Guidebook recommended how the retention of those structures could be integrated into forest management at the landscape and stand levels (B.C. Ministry of Forests and BC Environment 1995). Today it is common practice to set aside portions of each harvest block as Wildlife Tree Patches.

Purpose of this Report and Target Audience

The main challenge in managing wildlife diversity is accommodating the large number of wildlife species and their great variety of habitat requirements. In north-central British Columbia, for example, the habitat needs of nearly 200 terrestrial vertebrate species, including 133 species that use WTs or CWD, are affected by forest management and must be considered in the integration of wildlife diversity and timber resource use. Research on wildlife diversity has proliferated since the early 1980s, and a wealth of knowledge on habitat requirements has accumulated.

The purpose of this document is twofold: 1) to introduce Habitat Summary Tables as a framework for condensing large volumes of existing information on wildlife habitat requirements in a format based on biological patterns; and 2) to present WT- and CWD-related Habitat Summary Tables that were prepared in 1994 and 1995, respectively, and that describe in detail the varieties of WTs and CWD required by wildlife. The tables are intended for use primarily by wildlife professionals, foresters, and others involved in managing habitat to maintain wildlife diversity in north-central British Columbia. However, anyone requiring wildlife habitat information in a condensed format may find the tables useful.

Scope of the Report

Habitat elements: The Habitat Summary Tables presented in this report focus on wildlife requirements involving two special habitat elements that are directly affected by forest management: Wildlife Trees and Coarse Woody Debris.

Wildlife species and biogeoclimatic zones: Covered in this report are the habitat needs of all 133 terrestrial vertebrate species that use WTs or CWD and that have been recorded, or that potentially occur, in the Sub-Boreal Spruce (SBS), Engelmann Spruce – Subalpine Fir (ESSF), and Interior Cedar – Hemlock (ICH) biogeoclimatic zones north of 52°N. This latitude extends through the vicinities of Kleena Kleene, Alexis Creek, Williams Lake, Mahood Lake, Blue River, and the Columbia Icefield.

Information sources: Information was gathered mainly from literature published up to 1994 and 1995, for WTs and CWD, respectively. Emphasis in the review was on results of original research. Although the literature search was extensive, some important papers were undoubtedly missed and some were unobtainable within the time constraints of the project. A bibliography of the reviewed literature is provided in the Appendix. Additional information was provided by researchers involved in current local projects and by other wildlife experts.

Geographic applicability: Habitat information was compiled from studies conducted throughout each wildlife species' range. Examining habitat use patterns from different geographic areas was an important aid in the identification of critical habitat features (outlined on page 3).

Most of the critical features listed in the Habitat Summary Tables represent fundamental needs of the animals (e.g., WT size or degree of concealment of CWD-associated spaces) that are likely to be valid throughout the ranges of the wildlife species. The actual descriptions of these features (e.g., >27 cm dbh for aspen/birch in Wildlife Tree Table 2-1, or the lists of reported forms of concealment shown in many CWD tables) represent measurements or forms of the critical features that have been reported to be suitable. Because research information collected in north-central British Columbia is scarce for most wildlife species, these descriptions are based mainly on studies conducted elsewhere. Care was therefore taken to exclude any information that may represent local habitat use patterns unlikely to be valid in the SBS, ICH, and ESSF zones in north-central British Columbia. The applicability of research findings to these zones was evaluated by examining the similarity of the study areas to ecosystems in these zones (including presence of competing wildlife species that may have influenced reported habitat use patterns) and by assessing the geographic constancy of the findings.

Most of the descriptions of critical features are probably also valid in the Interior Douglas-fir (IDF), Montane Spruce (MS), Sub-Boreal Pine – Spruce (SBPS), Boreal White and Black Spruce (BWBS), and Spruce – Willow – Birch (SWB) biogeoclimatic zones in British Columbia, although some differences exist in the occurrence of tree and wildlife species. Descriptions are probably least applicable to the southern Coast (Coastal Western Hemlock [CWH] and Coastal Douglas-fir [CDF] zones) and the very dry Interior (Ponderosa Pine [PP] zone), which are most dissimilar from forest types in the majority of studies from which habitat information was extracted. However, only field research can provide definite confirmation of the applicability of the descriptions to the SBS, ICH, ESSF, and other zones.

The Concept of "Types"

"Types" are integral to the condensing of habitat information: The summarizing of information on wildlife habitat requirements was achieved through delineating "Types" of habitat. This process began with reviewing the literature and recording, for each wildlife species, all habitat requirements involving WTs and CWD. Some of these requirements were statistically substantiated *preferences* (i.e., habitat parameters being used significantly more than in proportion to their availability). However, the information extracted from most studies represented only observed habitat *use* because actual preferences had not been determined.

As the list of required habitat attributes grew, two patterns emerged that could be used to condense this information:

1. Commonly, several different reported habitat requirements described, or were correlated with, the same underlying "critical feature." The list of reported habitat needs could be greatly shortened by identifying and including only these underlying critical habitat features. This approach was particularly helpful for condensing the often attribute-rich descriptions of habitat needs relating to WT or CWD surroundings.

   Correlation with a critical feature frequently made habitat characteristics appear required that had no function. For example, 86% of Pileated Woodpecker nest trees found in an Oregon study were situated on ridge tops or on the mid-upper third of slopes (Bull 1987). This affinity for higher ground may not have been due to any requirement for this characteristic itself, but to the correlation between slope position and presence of a preferred tree species, ponderosa pine, which grew on these higher sites. This tree species possessed critical features that were important for cavity construction, such as a sufficiently large size.

   The identification of underlying critical features was based mainly on the various study authors' interpretations of the habitat use patterns they found. Those explanations were supplemented by reviewing further information on the functional significance of possible critical features (e.g., warm roost temperatures are important to ensure rapid growth of young Little Brown Myotis before and after birth, which ultimately increases their chance of surviving their first winter [Fenton and Barclay 1980; Barclay 1982]), and by assessing the geographic constancy of their use (i.e., features that consistently receive much use throughout a species' range are likely to represent fundamental needs). Some critical features were easy to identify because they represent obvious necessities (e.g., a sufficiently large tree diameter is required to accommodate a nest or roost cavity).

2. Critical features could be grouped into sets, each of which represents a configuration of WT or CWD features that is used by a number of different wildlife species for specific functions. Considering features in sets resulted in further consolidation of the list of habitat requirements and allowed groups of wildlife species to be treated collectively. The sets, or configurations, of critical features are the "Types" that form the basic units of the Habitat Summary Tables. Types are thus not preconceived categories, but habitat use patterns that emerged from the review of available wildlife habitat information.

With this approach, the habitat requirements of the 79 species of WT users and the 78 species of CWD users of north-central British Columbia were condensed into 10 WT Types and 6 CWD Types. For each Type, the critical features that define it were described in as much detail as available information allowed. At this level, the focus shifted from a need to condense information to a need to find more information to fill knowledge gaps. Descriptions of critical features show the forms or quantitative values that have been reported to be preferred or commonly used, and that can therefore be considered suitable. Further literature review and local field research are likely to widen the ranges of most of the values and qualitative characteristics shown in the tables, but some may become narrower to accurately reflect specific habitat needs in north-central British Columbia.

Although the system of Types helped to organize and greatly condense existing habitat information, much complexity and variation remains throughout the summary tables. Examples are the different strengths of association of wildlife species with a Type and the "Special Requirements" of some species within a Type. Also important is the need to include the context of the surrounding habitat among the critical features of WT and CWD Types, because research has shown that animals do not perceive these habitat elements in isolation.

Definition of "Type": A Type is a specific configuration of habitat features that seems to be required by at least one wildlife species for specific functions. For example, Wildlife Trees of Type 6 (WT-6: Cracks, Loose Bark, or Deeply Furrowed Bark) seem to be required by Brown Creepers for nesting.

Most critical features are not mutually exclusive. A single WT or piece of CWD can have the features of more than one Type and may therefore serve several functions for several groups of wildlife species. In theory, all Types must be present to maintain the full complement of native wildlife species. However, field testing is required to verify this hypothesis.

Format and Contents of the Tables

There are five summary tables for WTs (listed below) and five corresponding tables for CWD:

Table 1: Types of Wildlife Trees, arranged by function, that are required by wildlife species occurring in the SBS, northern ESSF, and northern ICH biogeoclimatic zones

Table 2: Descriptions of each of the 10 Types of Wildlife Trees listed in Table 1

Table 3: Cross-reference summarizing the associations of wildlife species with the 10 Types of Wildlife Trees

Table 4: The 79 vertebrate species that are associated with Wildlife Trees and have been recorded, or potentially occur, in the SBS, northern ESSF, and northern ICH biogeoclimatic zones

Table 5: Research needs relevant to Wildlife Tree management

Table 2 of the WT chapter, and Table 7 of the CWD chapter contain the entire condensed habitat information. The other tables provide no further information, but are references to specific components of Tables 2 and 7.

Within Tables 2 and 7, there is one subtable for each Type, describing it in detail (e.g., Table 2-1, 2-2, etc.). Footnotes offer additional information,

including literature references for some citations of data from specific studies. It was not practical, within the condensed table format, to directly link all entries to all the literature sources from which information was derived. Instead, literature sources are provided as a bibliography in the Appendix. Terms and symbols used in the tables are defined on pages 13–17.

The format and contents of the subtables of Tables 2 and 7 are explained below.

COLUMN 1: FUNCTION AND WILDLIFE SPECIES ASSOCIATED WITH THE TYPE

Function: Only main functions are considered. Other, often incidental, uses that are not tied to specific configurations of habitat features and that would not require specific management attention are not considered in the delineation of Types and are not mentioned in column 1. For CWD, such other functions are very numerous and are listed in an addendum to Table 6, because awareness of these additional functions may help habitat managers to estimate the required overall abundance of CWD.

Wildlife species: The list of wildlife users shown for each Type is subdivided according to the strength of each species' association with the Type. These three levels of relative importance of a Type (marked ■, ◪, and □) are defined on page 16. Table 2-4 indicates, for example, that Wood Ducks (■) tend to be restricted to (or strongly prefer) WT-4 for reproduction/resting, whereas Northern Hawk Owls (◪) use WT-4 as well as other Types for this function without apparent strong preferences, and Merlins (□) make only occasional use of WT-4 for reproduction/resting. For WT-10 (hunting perches), definitions had to be worded slightly differently because species may use alternative kinds of perches as well as alternative hunting techniques. The lists of occasional users of each Type (marked □) depend on reports of incidental observations and are likely to be incomplete.

An overview of the Types used by each wildlife species is provided by Tables 3 and 8. Table 3 shows, for example, that the alternative WT Types used by Northern Hawk Owls for reproduction/resting are WT-4 and WT-8, and that for foraging, this species primarily uses WT-10. Human-made structures, such as nest boxes, are not considered alternative Types.

COLUMN 2: TREE SPECIES AND DECAY CLASSES (OR LOG DECOMPOSITION CLASSES) IN WHICH THE TYPE OCCURS MOST COMMONLY

The purpose of column 2 is to indicate where the Type is most likely to be found. For WTs, tree species is a good guide to likely occurrences of specific Types. The tree species listed are those that most commonly possess or develop the combination of critical features that characterizes the Type, and that are commonly used by the wildlife species associated with the Type. Only tree species occurring in the SBS, northern ESSF, and northern ICH biogeoclimatic zones are mentioned. Occurrence of CWD Types was not found to be clearly related to any site parameters or to tree species.

Column 2 also shows how each Type relates to classification systems commonly used in British Columbia: the Decay Classes of the B.C. Wildlife Tree Classification (Wildlife Tree Committee of British Columbia 1997) or the Log Decomposition Classes of Maser et al. (1979, p. 80). However, Types generally do not correspond directly to the categories of these classification systems,

because the design of these systems was not based primarily on wildlife requirements but on decomposition sequences. For example, WT-1 trees are most likely to be found in Decay Classes 2, 3, or 4, but not all trees in these classes are WT-1—that is, not all have "internal decay surrounded by hard outer wood" and other critical features of WT-1.

COLUMNS 3 TO X: CRITICAL FEATURES OF THE TYPE

The remaining columns detail the critical features of the Type. Critical features are those that best describe the actual requirements that underlie observed habitat use patterns. These requirements are determined by physiological, security-related, social, or other universal or locally specific needs. Some examples and further explanations are provided on pages 3 and 13. Critical features may pertain to the WT or CWD itself, or to its location with respect to the surrounding habitat. Features pertaining to location reflect stand-level requirements as well as landscape-level considerations such as habitat interspersion and stand connectivity.

The number of critical features varies among Types. Descriptions of critical features are as detailed as available information permits. Where data from natural sites are insufficient, descriptions of successfully used human-made structures (e.g., nest boxes or bat roosts in buildings) are included in the characterization of a Type's critical features. Information on wildlife needs related to CWD is generally limited, and actual measurements of critical CWD features are very scarce, partly because some features are difficult to quantify (e.g., degree of concealment).

Many critical features, such as the pattern of wood decay in WT-1, are quite specific, but others are not. For example, several species require "some tree cover" around CWD-5, but appear to be flexible with respect to the exact characteristics of this tree cover, such as the degree of crown closure or the tree species composition. Such flexibility is especially prevalent in the case of CWD, where the functions of many critical features (e.g., small concealed spaces for nesting, resting, and escape) can be served by a great variety of forms, decay stages, and sizes of CWD. Most wildlife species associated with the Types that serve structural functions (CWD-1 to 5) are not even restricted to CWD for these functions (i.e., presence of wood does not appear to be critical). Non-woody materials (rocks and cutbanks) therefore had to be included in these Types to more closely reflect the animals' perception of their habitat. Without this broader definition, none of the wildlife species associated with CWD-2 to 5 could be said to require these Types (i.e., none would be marked ■). Because many critical features of CWD have such wide ranges and are also very common, the same piece of CWD very often serves as more than one Type. In particular, CWD-2, 4, and 6 frequently occur together.

Some of the critical features, such as internal tree decay, are not readily visible. For these features, indicators are described (as far as this information exists) to help detect them in the field.

Variation in habitat requirements occurs even within a Type. To absorb some of it, ranges of values (e.g., a range of tree diameters) have been specified that satisfy all wildlife species associated with a particular Type. More substantial variations are shown as "Special Requirements," such as the need of Pileated Woodpeckers for a much greater tree diameter than that required by the other species using WT-1. Nearly all critical features pertaining to the

location of WTs or CWD are special requirements that are important for only some of the wildlife species associated with a particular Type. For each special requirement, the pertinent wildlife species are shown in parentheses. Special requirements are mentioned only for the main users of a Type (those marked ■ or ◪ in column 1), not for occasional users (marked □).

Content Limitations

The Habitat Summary Tables represent a framework with many information gaps.

During the preparation of the summary tables, many research needs were identified. Knowledge gaps were particularly extensive in the case of CWD. The delineation and description of CWD Types presented in this report should therefore be considered preliminary.

The summary tables will require periodic updates as new information becomes available. Because the tables were prepared in 1994/95, it is clear they lack recent research findings.

Furthermore, although it is hoped that most of the requirements pertaining to the habitat surrounding the WTs and CWD have been addressed in the entries on tree and CWD location, there likely are some omissions and inaccuracies regarding this extensive topic. A complete detailed review of each wildlife species' entire habitat would have been valuable, but was beyond the scope of this project.

The Habitat Summary Tables do not include information on the required numbers and spatial distribution of WTs or CWD of each Type.

Exact relationships between wildlife population sizes and habitat quantity are difficult to determine, especially when groups of wildlife species are considered collectively, as in the Types. Consequently, information is scarce. However, a general indication of the relative quantities needed of each Type may simply be derived from the number of associated wildlife species (i.e., Types used by many species are needed in greater quantities).

Also missing from the tables are wildlife requirements pertaining to the spatial distribution of WTs and CWD (e.g., whether these elements should be clumped or scattered and how far apart they should be). Research results on this topic are equally scarce and their integration into the summary tables would again be complicated by the collective treatment of species.

Potential Applications of the Tables

The Habitat Summary Tables have a wide range of potential applications. For example, they can be used in the following tasks:

Forest and wildlife management:

- designating Wildlife Tree Patches (B.C. Ministry of Forests and BC Environment 1995, pp. 62–70)
- selecting and evaluating other kinds of reserves, including forest ecosystem networks, riparian reserves, and old-growth reserves
- planning for intensively managed areas, such as woodlots and community forests
- identifying trees and CWD with high wildlife value to be retained during forestry operations
- assessing effects of forestry practices on biodiversity attributes
- conducting forest and wildlife habitat inventories

Nature education and conservation:

- preparing interpretation and education programs in parks, nature reserves, and community forests
- conducting park planning
- providing information to help private landowners enhance habitat

Wildlife habitat research:

- assessing habitat values during selection of study areas
- standardizing data collection (by using Types to describe and quantify habitat)
- identifying research needs

Some Practical Considerations in Applying the Tables

It is recommended that users keep in mind the following points when applying the tables of WT and CWD Types in habitat management:

- Different ecosystems are likely to have different frequencies of the various Types. All Types will not usually occur within a single stand. The maintenance of all Types and associated special requirements must therefore be planned and co-ordinated over a larger area. Inventory information showing which Types are common and which are rare in various ecosystems would be an important aid to this management approach.

- Many Types, such as the eight WT Types used for reproduction/resting and the CWD Type providing large concealed spaces, tend to be uncommon or rare in most ecosystems. Their maintenance may require special management attention. Rare Types may need to be retained wherever they are encountered. The recruitment of these Types is naturally low and usually depends on rare chance events. The likelihood of their future development is even lower in managed forests, because the total number of trees in the forest "pool" is reduced through logging, and because silvicultural practices such as stand tending, stand sanitation, site conversion, and short rotations generally impede the development of WTs and large CWD. It may be necessary to promote the recruitment of rare and uncommon Types by:
  - encouraging the specific factors that lead to the development of these Types, and/or
  - creating these Types directly, such as by providing artificial structures that mimic the critical features of the Types (e.g., nest supports in suitable trees for users of WT-8).

- Within each Type, some trees that provide for the "Special Requirements" of particular wildlife species should be present. Most special requirements pertain to WT or CWD location. For example, among the trees that can serve as WT-4 (trees with large cavities), some should, for instance, be located in dense cover, some should be <100 m from open water, and some should be in stands connected by travel corridors if stands are >100 m apart. Furthermore, if a species has several special requirements, those should be combined in the same tree. For example, some WT-4 trees should be near water and have dense cover concealing the nest entrance to be valuable for Wood Ducks (Semel and Sherman 1993).

- Ensuring continuous availability of each Type involves retaining WTs and CWD having current wildlife value, as well as trees that are likely to develop the critical features of the various Types in the future.

- Managing for future development of all Types requires having some knowledge of the ecology of their critical features. Such information is beyond the scope of this report, but is important to aid the selection of likely trees for future recruitment, to ensure that the processes leading to the development of the critical features are not disturbed inadvertently, and to guide efforts aimed at encouraging the development of these features. The following points are examples of such ecological considerations:
  - Factors (e.g., site conditions or disturbance agents) and time frames involved in the development of particular critical features
  - Natural probability of the development of particular critical features: Even if the most likely trees have been chosen for future recruitment, not all of them will actually develop the critical features. Having some estimate of the natural frequency of these features within the population of likely trees would help determine how many trees should be retained to ensure adequate recruitment.
  - Average length of time that WTs or CWD (of a certain tree species) are usable as a particular Type. It should be noted that the usable timespan of a WT Type may end before the tree falls if critical features disappear. For example, cavities dug through live sapwood eventually scar over and become unavailable to the secondary cavity users of WT-3 and WT-4.
  - Linkage of some Types in development: An obvious example is the creation of WT-3 or WT-4 (trees with existing cavities) by primary cavity excavators as they use WT-1 or WT-2.
  - Specific ecology of deciduous trees: Especially in the central and northern Interior of British Columbia, deciduous trees form a major portion of the WT resource, particularly of the Types used for reproduction/resting. Ecological characteristics of deciduous trees that are relevant to WT management, especially for planning future recruitment, include:
    - a relatively limited, often patchy distribution in most biogeoclimatic zones and a further restriction of large trees to particularly favourable sites;
    - a relatively short-lived seral nature;
    - the importance of *live* trembling aspen as WTs, even as substrates for cavity excavation, and their relatively short persistence after tree death; and
    - the clustered distribution of aspen with similar features (including decay characteristics [Hiratsuka and Loman 1984]) due to the dominant, asexual mode of reproduction by root-suckering, which results in clusters of clones.

SUMMARY OF THE REPORT

This report introduces a framework for condensing information on wildlife habitat requirements. Summarized are the habitat needs of wildlife species that occur in north-central British Columbia and that use the special habitat elements Wildlife Trees and Coarse Woody Debris.

The information, compiled mainly from the published literature up to 1995, is presented as a series of Habitat Summary Tables that emphasize the critical habitat features underlying reported habitat use patterns, and that consider groups of wildlife species collectively. Critical features include characteristics of the special habitat elements, as well as requirements relating to the surrounding habitat. The features form sets, termed "Types," each of which is used by several different wildlife species for specific functions. The identification of critical features was based on the interpretations that the authors of the various habitat studies provided for their results, and on further reviews of the features' functional significance and geographic constancy of use.

The requirements of 133 wildlife species were condensed into 10 Types of Wildlife Trees and 6 Types of Coarse Woody Debris. Each Type is described in terms of the critical features that define it, its overall function, and the wildlife species that use it. The wildlife species are differentiated according to the strength of their association with the Type. Also shown in the Habitat Summary Tables are the tree species in which each Wildlife Tree Type is most likely to occur, and the relationship of Types to common classification systems for the two special habitat elements. Field indicators are provided for some of the features that are not readily visible, and special requirements are described to address variability among wildlife species within the same Type. Not included is information on required quantities and spatial distribution of Wildlife Trees or Coarse Woody Debris. Many specific research needs are indicated throughout the tables.

The Habitat Summary Tables have a wide range of potential applications in forest and wildlife management, nature education and conservation, and wildlife habitat research.

LITERATURE CITED IN THIS DOCUMENT

Only references cited in this guide and in footnotes and captions of the Habitat Summary Tables are shown here. A complete bibliography of the literature consulted in the preparation of the tables is provided in the Appendix.

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Habitat Summary Tables

DEFINITIONS AND SYMBOLS

CAVITY HEIGHT (ABOVE GROUND)—*see* TREE DIAMETER

CHAMBER DIMENSIONS—*see* ENTRANCE DIAMETER

COARSE WOODY DEBRIS (CWD)

Coarse Woody Debris includes logs and rooted trunks at an angle of <45° with the ground surface, stumps <1.3 m in height, large detached branches and slabs, large exposed roots, and upturned rootmasses. Taller stumps and more upright logs and rooted trunks are considered Wildlife Trees (WTs).

Most wildlife species associated with the CWD Types that serve structural functions (CWD-1 to CWD-5) do not appear to differentiate between using CWD or non-woody material for these functions (i.e., presence of wood is not a critical feature). To reflect this habitat use pattern, non-woody materials (rocks and cutbanks) are included in CWD-1 to 5, in addition to CWD.

Likewise, wildlife species associated with CWD-1, 2, 3, and 6 may not differentiate between CWD and tree bases that have the critical features of these Types. Bases of standing trees are therefore included in these Types.

CRITICAL FEATURES

Critical features are the actual requirements that are represented by, or that underlie, observed patterns of habitat use and that reflect physiological and other needs. For example, the observed preference of WT-1 users for nesting in aspen and certain other tree species is due largely to the prevalence of critical wood decay features in these trees. The decay features are necessary because they allow secure nest cavities to be built in substrates that do not exceed the woodpeckers' physical excavation capabilities.

DECAY CLASSES

Decay Classes are the nine classes of the B.C. Wildlife Tree Classification System (Wildlife Tree Committee of British Columbia 1997).

Note: The Decay Classes listed for each Type of WT should not be equated with these Types, because the Types' critical features are not necessarily present in all trees in the classes shown and may even occur in only a small proportion of trees in these classes.

ENTRANCE DIAMETER, CHAMBER DIMENSIONS

The values shown for these variables represent ranges of reported means, which are often relatively narrow (in some cases consisting of single values). Any value within these narrow ranges is probably suitable for all wildlife species associated with the Type. Values above or below the ranges may not be acceptable for all users of the Type. Only means of samples with $n \geq 15$ are included in the ranges, unless stated otherwise. Values are rounded to the nearest centimetre.

HUNTING PERCHES

Hunting perches in the forest interior, which are used by predators that rely primarily on their hearing to locate prey (e.g., Boreal Owl and Northern Saw-whet Owl), are not included in this report because these perches are not considered WTs. They possess no special characteristics (e.g., an open structure or a location in or next to open areas) that would distinguish them from most other trees. The Boreal Owl and Northern Saw-whet Owl are included as ◪ users of WT-10 because they also hunt from perches located in or next to clearings.

IMMEDIATE SURROUNDINGS

"Immediate Surroundings" refers to requirements at a "patch" scale—that is, right around the WT or CWD. Examples are an unobstructed flight path to the nest or dense vegetation for nest concealment or thermal cover. For small species whose home ranges are largely contained in the patch around the WT or CWD, "Immediate Surroundings" also describes general habitat needs that are not directly related to these two special habitat elements. For more mobile species, general forest habitat needs are shown under "Proximity to Specific Forest Stands." In most of the WT studies reviewed, plot sizes for sampling the immediate surroundings of nest, roost, or foraging trees ranged from 0.1 to 0.4 ha. No data are available on the actual wildlife requirements regarding the sizes of the patches with the features described under "Immediate Surroundings," for WTs or CWD.

KNIFE TEST

The Knife Test is used to rank relative wood hardness (slightly modified from Harris 1983). It is based on the penetration of a knife blade following a "standardized" thrust (after bark has been removed):

Very hard:	**<1 cm**
Hard:	**≥1 cm and <2 cm**
Soft:	**≥2 cm and <5 cm**
Rotted:	**≥5 cm**

Very few test scores using the above scale are available for trees used by species other than the Pileated Woodpecker.

LOCATION OF THE CWD—*see* TREE LOCATION

LOG DECOMPOSITION CLASSES

Log Decomposition Classes refer to the five-class system described by Maser et al. (1979, p. 80).

Note: The Log Decomposition Classes shown for each Type of CWD should not be equated with any of these Types, because the critical features of each Type are not necessarily present in all logs in the classes shown.

MAXIMUM DISTANCE FROM FOREST

This critical feature refers to the limited distance that some species will travel from forest to use WTs or CWD in open areas.

MINIMUM STAND SIZE

"Minimum Stand Size" pertains to the size of forest fragments (in unforested areas) that contain WTs or CWD of a particular Type. It does not refer to the animals' total forest area requirements. Although important, the latter is beyond the scope of this report. In addition to adequate stand size, sufficient distance of the WTs or CWD away from the forest edge is probably critical for some forest-interior species. Furthermore, if WTs or CWD are located in unforested areas, the size of nearby forest stands may be important, but no research was found addressing this hypothesis.

NATURAL CAVITIES

"Natural Cavities" are tree holes caused by decay and/or mechanical damage. Cavities resulting from the excavation of nests, roosts, or feeding holes by primary cavity excavators are not included.

PROXIMITY TO SPECIFIC FOREST STANDS

This entry summarizes critical features of the general forest habitat if these features are required in close proximity to the WTs or CWD. No information on actual distances was found. Requirements for nearby unforested habitat are addressed under "Proximity to Open Areas or Edge."

STAND CONNECTIVITY

"Stand Connectivity" refers to the need for travel corridors that connect forest fragments containing the WTs or CWD to the rest of an animal's habitat. Travel corridors are needed if unforested areas form a barrier to movements or impose an increased energy expenditure or predation risk when crossed.

TREE DIAMETER, CAVITY HEIGHT (ABOVE GROUND)

The sizes shown in bold will satisfy all wildlife species associated with the Type, except those with "Special Requirements." Values in parentheses are suitable for some but not all of the species. To arrive at the figures, the lowest reported means were considered for each of the wildlife species. The highest value in this range (i.e., the mean for the species requiring the greatest size) is the one shown in bold. The lowest value in the range is the one in parentheses, but it is not shown if the range is very narrow. If actual preferences are known, they are used instead of the reported means for the species. Research findings are included only if sample sizes are ≥5. Tree diameters are rounded to the nearest centimetre. The needs of occasional users of a Type (marked □) are not considered.

TREE LOCATION, LOCATION OF THE CWD

Entries under these headings deal with the need for WTs or CWD to be located near suitable habitat (see "Proximity to Specific Forest Stands," "Proximity to Open Areas or Edge," and "Proximity to Water"). Requirements relating to the location of WTs or CWD in a fragmented forest landscape are also addressed (see "Minimum Stand Size," "Maximum Distance from Forest," and "Stand Connectivity"), as are patch-scale

habitat features required right next to the WTs or CWD (see "Immediate Surroundings").

TREE SPECIES

Tree species considered: **SBS zone**: hybrid white spruce (*Picea glauca* x *engelmannii*), black spruce (*Picea mariana*), subalpine fir (*Abies lasiocarpa*), interior Douglas-fir (*Pseudotsuga menziesii* var. *glauca*), lodgepole pine (*Pinus contorta* var. *latifolia*), paper birch (*Betula papyrifera*), trembling aspen (*Populus tremuloides*), and black cottonwood (*Populus balsamifera* ssp. *trichocarpa*); **northern ESSF zone**: Engelmann spruce (*Picea engelmannii*), subalpine fir, lodgepole pine, and whitebark pine (*Pinus albicaulis*); and **northern ICH zone**: western redcedar (*Thuja plicata*), western hemlock (*Tsuga heterophylla*), white spruce (*Picea glauca*), Engelmann spruce, and all species listed for the SBS zone.

WILDLIFE SPECIES

Strength of association of species with WT-1 to WT-9, and with the Types of Coarse Woody Debris:

- ■ Species that seem to be restricted to the Type or that appear to strongly prefer it
- ◪ WT Types: Species that use alternative Types (or habitat elements other than WTs) for the same function, without apparent strong preferences
- ◪ CWD Types: Species that use alternative Types (or habitat elements other than CWD, rocks, or cutbanks) for the same function, without apparent strong preferences
- □ Species that have been reported to use the Type occasionally

Strength of association of species with WT-10:

- ■ Species that hunt primarily from perches of Type WT-10
- ◪ Species that hunt from perches of Type WT-10 as well as other perches (not considered WTs), and species that perch-hunt from WT-10 as well as using alternative hunting techniques
- □ Species that occasionally perch-hunt using WT-10, but primarily use other hunting techniques

Species with restricted distributions:

(L) Lower-elevation species: Unlikely to occur in the ESSF zone

(H) Higher-elevation species: In southern areas, restricted mainly to the ESSF zone. At higher latitudes, the species occurs at lower elevations (i.e., it may occur in northern parts of the SBS zone).

(S) Southern species: Occurs in the ICH, SBS, and (unless marked as a low-elevation species) in the ESSF zone, but its occurrence north of

	latitude 52°N (in Interior British Columbia) is sparse or localized.
(Sh) Southern species of humid microclimates:	Associated mainly with humid, shady sites in the ICH zone. May also be found in similar microclimates in the SBS and ESSF zones.
(N) Northern species:	Unlikely to occur in the ICH zone, although it may be present in the northwestern patch of ICH that is found in the Prince Rupert Forest Region.

WILDLIFE TREE (WT)

For the purposes of this report, a Wildlife Tree is defined as a standing dead or live tree with special characteristics that are valuable for wildlife and that distinguish the tree from most other trees in the forest. Stumps <1.3 m in height and logs or rooted trunks at an angle of <45° with the ground surface are considered to be Coarse Woody Debris.

WILDLIFE TREES

Table 1 Types of Wildlife Trees, arranged by function, that are required by wildlife species occurring in the SBS, northern ESSF, and northern ICH biogeoclimatic zones 18

Tables 2-1 to 2-10 Descriptions of each of the 10 Types of Wildlife Trees listed in Table 1 19

Table 3 Cross-reference summarizing the associations of wildlife species with the 10 Types of Wildlife Trees listed in Table 1 and described in Tables 2-1 to 2-10 32

Table 4 The 79 vertebrate species that are associated with Wildlife Trees and have been recorded, or potentially occur, in the SBS, northern ESSF, and northern ICH biogeoclimatic zones 34

Table 5 Research needs relevant to Wildlife Tree management 36

TABLE 1 *Types of Wildlife Trees (WTs),[1] arranged by function, that are required by wildlife species occurring in the SBS, northern ESSF, and northern ICH biogeoclimatic zones. Only those configurations of features that appear to be required (i.e., marked ■ in Table 2) by at least one wildlife species are delineated as individual Types. Most Types are not mutually exclusive (i.e., two or more Types can occur together in the same tree). Complete descriptions of each Type are provided in Tables 2-1 to 2-10.*

Main functions of Wildlife Trees	Configurations of Wildlife Tree features required by wildlife species occurring in the SBS, ESSF, and ICH zones		Main users
Reproduction/Resting: a. Substrates for excavation of cavities	WT-1:	Hard Outer Wood Surrounding Decay-Softened Inner Wood	Woodpeckers (stronger excavators)
	WT-2:	Outer and Inner Wood Softened by Decay	Woodpeckers (weaker excavators), chickadees, Red-breasted Nuthatch
Reproduction/Resting: b. Existing cavities	WT-3:	Small, Excavated or Natural Cavities	Chickadees, nuthatches, Northern Pygmy-Owl, swallows, other passerines, bats
	WT-4:	Large, Excavated or Natural Cavities	Ducks, American Kestrel, owls, Mountain Bluebird, European Starling, Northern Flicker, swallows, other passerines, bats, squirrels, Marten
	WT-5:	Very Large Natural Cavities and Hollow Trees	Vaux's Swift, mustelids, Barred Owl, bats, Red Squirrel
	WT-6:	Cracks, Loose Bark, or Deeply Furrowed Bark	Brown Creeper, bats
Reproduction/Resting: c. Large open-nest supports and other non-cavity sites	WT-7:	Witches' Brooms	Squirrels, mustelids, Merlin, owls
	WT-8:	Large Branches, Multiple Leaders, or Large-Diameter Broken Tops	Great Blue Heron, diurnal raptors, owls, Common Raven
Foraging: a. Feeding substrates	WT-9:	Arthropods in Wood or under Bark[2]	Woodpeckers
Foraging: b. Hunting perches	WT-10:	Open-Structured Trees in or adjacent to Open Areas	Diurnal raptors, owls, various passerines, Belted Kingfisher

1 Trees used for sap-feeding are not considered WTs because no information was found to indicate that they have special characteristics that distinguish them from most other trees in the stand. If future research shows that special characteristics are required for sap-feeding (e.g., sap with a high sugar content or flow volume), then trees with such features should be included as an additional WT Type. Active sapwells would be reliable field indicators. Although not regarded as WTs in this report, tree species used for sap-feeding are included as critical stand features of the habitat near WT-1.

2 Arthropods on tree surfaces or in shallow bark irregularities are not included in this report. Presence of such prey is not considered a special characteristic that would define trees as WTs.

TABLES 2-1 to 2-10. Descriptions of each of the 10 Types of Wildlife Trees (WTs) listed in Table 1. Types are described in terms of their critical features, reported values or forms of these critical features, overall function, associated wildlife species, and the tree species and Decay Classes in which the Type is most commonly found. Wildlife and tree species considered are those that occur in the SBS, northern ESSF, and northern ICH biogeoclimatic zones. "Special Requirements" pertain to only some of the wildlife species associated with the Type. Descriptions of Types are based mainly on habitat research results compiled from the literature. Question marks indicate that further information or confirmation of local applicability is needed. Terms and symbols are explained on pages 13–17. Footnotes follow Table 2-10. All information presented is current only to 1994.

TABLE 2-1 *WT-1: Hard outer wood surrounding decay-softened inner wood*

Function and wildlife species associated with WT-1	Tree species and Decay Classes in which WT-1 occurs most commonly	Critical features of WT-1: Wood decay characteristics	Sapwood condition (live vs. dead)	Tree size and structure	Tree location
FUNCTION **Reproduction/Resting:** Substrates for excavation of nest or roost cavities **WILDLIFE SPECIES** (*SBS, ESSF, ICH zones*) ■ Yellow-bellied Sapsucker (L,N) (*rare*) ■ Red-naped Sapsucker (S) ■ Red-breasted Sapsucker ■ Hairy Woodpecker ■ Three-toed Woodpecker ■ Black-backed Woodpecker ■ Pileated Woodpecker ?□ or ◪ Northern Flicker	**TREE SPECIES** *SBS zone:* **Trembling aspen** **Black cottonwood** *Others often used by Three-toed and Black-backed Woodpeckers:* Spruces Subalpine fir Lodgepole pine *ESSF zone:* *tentative – data scarce* **Subalpine fir** *Less commonly ?:* Engelmann spruce Lodgepole pine *ICH zone:* *tentative – data scarce* **Western redcedar ?** **Western hemlock ?** **Trembling aspen** **Black cottonwood** *Others often used: same as for SBS zone* **DECAY CLASSES** **2, 3, 4**	**INTERNAL DECAY[1] SURROUNDED BY HARD OUTER WOOD** A pocket of decay is sufficient. *For its above-ground position, see Tree Size: Cavity Height.* ***Field Indicators[2] of Internal Decay:*** **Existing excavated nest cavities[3]** Very reliable indicator. Excavated nest cavities have circular or oval, smooth-edged entrances. Aborted excavation attempts can usually be discerned by the funnel-shaped narrowing of the entrance. **Fruiting bodies of heartrot fungi** Very reliable indicator. Some heartrot fungi common in north-central B.C.: Trembling aspen, black cottonwood[4]: *Phellinus tremulae* Western hemlock, subalpine fir: *Echinodontium tinctorium* Western redcedar: *Phellinus weirii* Lodgepole pine, spruces: *Phellinus pini* **Broken-off tops** May be associated with internal decay as well as some dead sapwood (*see next column*). May be a useful indicator in black cottonwood and all ? conifers in the SBS zone[5], but not in trembling aspen. **Old trunk injuries** – Reliability ? ***Knife Test Score of Outer Wood Hardness:*** **Hard**	*Requirements for dead sapwood pertain only to the part of the tree in which the cavity is excavated (e.g., trunk top, one side of trunk, large branch). The whole tree need not be dead.* **DEAD[6] REQUIRED** Hybrid white spruce White spruce Engelmann spruce Black spruce ? Douglas-fir Lodgepole pine Paper birch Black cottonwood ? LIVE AND DEAD USED INDISCRIMINATELY Trembling aspen[7] Subalpine fir ? Western redcedar ? Western hemlock ?	**TREE DIAMETER** (dbh)[8] Aspen/birch: **>27 cm** Other species[9]: **>37 cm** ***Special Requirement:*** (Pileated Woodpecker): Aspen/birch: **>40 cm** Other species[9]: **>54 cm** **CAVITY HEIGHT** (above ground) **>(2) 4.8 m** ***Special Requirement:*** (Pileated Woodpecker): **>9.2 m** **BRANCH-FREE TRUNK PORTIONS ?** *(tentatively included as critical, no data available)* Length: sufficient to accommodate a nest/roost cavity in knot-free wood ? (e.g., 17–21 cm ? for sapsuckers, 38–58 cm ? for Pileated Woodpeckers)	*All features are* ***Special Requirements.*** **IMMEDIATE SURROUNDINGS** **Multi-layered, relatively dense canopy and numerous large trees[10]** (Pileated Woodpecker) **PROXIMITY TO SPECIFIC FOREST STANDS** **Coniferous forest** (Three-toed and Black-backed Woodpeckers) **Stands containing birch, large willows[11], or western hemlock** (sapsuckers) **PROXIMITY TO OPEN AREAS** **In or near open areas** (Northern Flicker, others ?[12]): ? *data on actual distances insufficient* **MINIMUM STAND SIZE** (Pileated, Three-toed, and Black-backed Woodpeckers, others ?): ? *data on actual sizes insufficient* **MAXIMUM DISTANCE FROM FOREST** (sapsuckers, Hairy Woodpecker): ? *no data on actual distances*

TABLE 2-2 **WT-2: Outer and inner wood softened by decay**

Function and wildlife species associated with WT-2	Tree species and Decay Classes in which WT-2 occurs most commonly	Critical features of WT-2		
		Wood decay characteristics and sapwood condition	Tree size	Tree location
FUNCTION **Reproduction/Resting:** Substrates for excavation of nest or roost cavities **WILDLIFE SPECIES** (*SBS, ESSF, and ICH zones*) ■ Downy Woodpecker[13] (L?) ?■ or ◪ Black-capped Chickadee ◪ Northern Flicker ?◪ or ☐ Mountain Chickadee ◪ Boreal Chickadee (H) ◪ Chestnut-backed Chickadee (Sh) (*rare*) ◪ Red-breasted Nuthatch ☐ Hairy Woodpecker ☐ Three-toed Woodpecker ☐ Black-backed Woodpecker ☐ White-breasted Nuthatch (L,S) (*rare*)	**TREE SPECIES** *SBS zone:* **Trembling aspen** **Paper birch** **Black cottonwood** **Douglas-fir**[14] **Subalpine fir ?** *ESSF zone:* *? data insufficient* *ICH zone:* *? data insufficient* **DECAY CLASSES** **5, 6, 7** also **2, 3, 4** if dead tree portions with the features of WT-2 are present	**INTERNAL DECAY ACCESSIBLE THROUGH DEAD DECAY-SOFTENED OUTER WOOD** A tree portion (e.g., dead top or trunk scar) with these features may be sufficient (i.e., the whole tree need not be dead). Some hard inner wood may be present if the softened outer wood is thick enough to accommodate a nest cavity. *For the above-ground position of the tree portion with suitable decay, see Tree Size: Cavity Height.* ***Field Indicators*[2] *of Internal Decay:*** **Existing excavated nest cavities**[3] (*as in Table 2-1*) **Fruiting bodies of heartrot fungi** Some heartrot fungi common in north-central B.C. (*see Table 2-1 for other tree species*): Paper birch: *Phellinus igniarius* and *Fomes fomentarius* Douglas-fir: *Fomitopsis pinicola* (also found on other tree species) and *Phellinus pini* **Old trunk injuries** – Reliability ? **Broken-off tops** Are a more reliable indicator for WT-2 than for WT-1, in all tree species, because broken tops are likely to occur in trees with the decay-softened outer and inner wood that characterizes WT-2. Trees with *rotted* outer wood (*see below*) and internal decay are especially likely to have broken tops. ***Knife Test Score of Outer Wood Hardness:*** **Soft**[15] (all species associated with WT-2 except chickadees) **Rotted** (Chickadees; Red-breasted Nuthatch uses both soft and rotted outer wood ?)	**TREE DIAMETER** (dbh)[5] Aspen/birch: >(13) **30 cm** Other species[6]: >(31) **37 cm** **CAVITY HEIGHT** (above ground) >(2.2) **4.7 m**	*All features are* ***Special Requirements.*** **PROXIMITY TO SPECIFIC FOREST STANDS** **Stands with deciduous vegetation** (Black-capped Chickadee) **Stands with coniferous trees** (Mountain, Boreal, and Chestnut-backed Chickadees, Red-breasted Nuthatch) **Older forest**[16] (Red-breasted Nuthatch) **PROXIMITY TO OPEN AREAS OR EDGE** ? *data on actual distances insufficient* **In or near open areas** (Northern Flicker) **Near edges if forests are closed** (Downy Woodpecker, chickadees) **MINIMUM STAND SIZE** (Downy Woodpecker, chickadees, Red-breasted Nuthatch): ? *no data on actual sizes* **MAXIMUM DISTANCE FROM FOREST** (species ?): ? *no data on actual distances* **STAND CONNECTIVITY** **Treed corridors or tree patches** (chickadees and nuthatches): required for crossing treeless ? areas >500 m ? wide

TABLE 2-3 *WT-3: Small, excavated or natural cavities*

Function and wildlife species associated with WT-3	Tree species and Decay Classes in which WT-3 occurs most commonly	Critical features of WT-3: Cavity size, above-ground height, and microclimate	Critical features of WT-3: Tree location
FUNCTION **Reproduction/Resting:** Existing cavities for nesting or resting **WILDLIFE SPECIES** (*SBS, ESSF, and ICH zones*) ■ White-breasted Nuthatch (L,S) (*rare*) ◪ Northern Pygmy-Owl ◪ Tree Swallow (L) ◪ Violet-green Swallow ? ◪ or ■ Mountain Chickadee ◪ Boreal Chickadee (H) ◪ Chestnut-backed Chickadee (Sh) (*rare*) ◪ Red-breasted Nuthatch ◪ House Wren (L,S) (*rare*) ◪ House Sparrow (*introduced*) ◪ Big Brown Bat ◪ Silver-haired Bat ◪ Western Long-eared Myotis ◪ Little Brown Myotis ◪ Northern Long-eared Myotis (*rare*) ◪ Long-legged Myotis ?☐ or ◪ Black-capped Chickadee ?☐ or ◪ Brown Creeper (roosting) ☐ Winter Wren ☐ Mountain Bluebird ☐ European Starling (*introduced*) ☐ Southern Red-backed Vole ☐ Deer Mouse ☐ Yellow-pine Chipmunk ☐ Least Weasel (*rare*)	**TREE SPECIES** *SBS zone:* **Trembling aspen** *Less commonly:* All other tree species *ESSF zone:* *tentative – data scarce:* **Subalpine fir ?** *Less commonly:* All other tree species *ICH zone:* *tentative – data scarce:* **Western redcedar** **Western hemlock** **Trembling aspen** *Less commonly:* All other tree species **DECAY CLASSES** **2, 3, 4** *Less commonly:* 5, 6, 7	**ENTRANCE DIAMETER** **4 cm**[17] ***Special Requirement:*** (chickadees, others ?): **3 cm**[18] **CHAMBER DIMENSIONS** *For excavated cavities, chamber dimensions are indicated by entrance diameter*[19] **Cavity depth:** **17–21 cm** **Cavity diameter:** **11–12 cm** *Not included:* Chickadee- and nuthatch-excavated cavity chambers are narrower ? *data insufficient* **CAVITY HEIGHT** (above ground) **>(2.2) 3.5 m ?** ***Special Requirement:*** (bats - maternity roosts): **>10 m** ***Special Requirements:*** **THICK, FIRM CAVITY WALLS** [20] (bats, others ?): ? *tentatively included as critical, no data available* **CAVITY TEMPERATURE** [21] (bats, others ?): **Warm and stable ?** Required temperatures for bats vary with roost type (maternity, day, night, or hibernation roost), female reproductive status, and bat species.	*All features are* ***Special Requirements.*** **IMMEDIATE SURROUNDINGS** **Unobstructed flight path to the cavity entrance**[22] (bats, swallows) **Sparse vegetation at and below nest height** (House Wren) **PROXIMITY TO SPECIFIC FOREST STANDS** **Stands with deciduous vegetation** (Black-capped Chickadee, House Wren) **Stands with coniferous trees** (Mountain, Boreal, and Chestnut-backed Chickadees, Red-breasted Nuthatch) **Older forest**[16] (Red-breasted Nuthatch) **Areas with low cover of shrubs or tall herbs** (House Wren) **PROXIMITY TO OPEN AREAS OR EDGE** ? *data on actual distances insufficient* **In or near open areas** (swallows, House Sparrow [near human habitation]) **Near edges if forests are closed** (chickadees, White-breasted Nuthatch, House Wren, Little Brown Myotis, other bats ?) **PROXIMITY TO WATER** **Near water** (Bats: *not critical where terrestrial habitats offer sufficient prey* ?) **MINIMUM STAND SIZE** (Northern Pygmy-Owl, chickadees, nuthatches, Big Brown Bat, Silver-haired Bat, other bats ?): ? *no data on actual sizes* **MAXIMUM DISTANCE FROM FOREST** (species ?): ? *no data on actual distances* **STAND CONNECTIVITY** **Treed corridors or tree patches** (chickadees, nuthatches, others ?): required for crossing treeless ? areas >500 m ? wide

TABLE 2-4 **WT-4: Large, excavated or natural cavities**

Function and wildlife species associated with WT-4	Tree species and Decay Classes in which WT-4 occurs most commonly	Critical features of WT-4: Cavity size, above-ground height, and microclimate	Critical features of WT-4: Tree location
FUNCTION **Reproduction/Resting:** Existing cavities for nesting, denning, or resting **WILDLIFE SPECIES** *(SBS, ESSF, and ICH zones)* ■ Wood Duck (L,S) (*rare*) ■ Common Goldeneye ■ Barrow's Goldeneye ■ Bufflehead (L) ■ Hooded Merganser (L) ■ American Kestrel ■ Boreal Owl (H) ■ Northern Saw-whet Owl ■ Mountain Bluebird ■ European Starling (*introduced*) ◪ Common Merganser (L) ◪ Northern Hawk Owl (H) ◪ Northern Pygmy-Owl ◪ Northern Flicker ◪ Tree Swallow (L) ◪ Violet-green Swallow ◪ House Wren (L,S) (*rare*) ◪ House Sparrow (*introduced*) ◪ Big Brown Bat ◪ Silver-haired Bat ◪ Western Long-eared Myotis ◪ Little Brown Myotis ◪ Northern Long-eared Myotis (*rare*) ◪ Long-legged Myotis ◪ Northern Flying Squirrel ◪ Red Squirrel ◪ Marten □ Merlin □ "Western Flycatcher" Complex (Sh?) (*rare*) □ Western Kingbird (L,S) (*rare?*) □ Barn Swallow □ Mountain Chickadee □ White-breasted Nuthatch (L,S) (*rare*) □ Winter Wren □ Townsend's Solitaire ?□ House Finch (L?,S) □ Hoary Bat (*rare*) □ Southern Red-backed Vole □ Bushy-tailed Woodrat □ Deer Mouse □ Yellow-pine Chipmunk □ Ermine □ Long-tailed Weasel □ Least Weasel (*rare*)	**TREE SPECIES** *SBS zone:* **Trembling aspen** **Black cottonwood** **Douglas-fir** *ESSF zone:* *? data insufficient* *ICH zone:* *tentative – data scarce:* **Western redcedar ?** **Western hemlock ?** **Trembling aspen** **Black cottonwood** **Douglas-fir** **DECAY CLASSES** **2, 3, 4, 5, 6, 7**	*For bats, data are very scarce.* **ENTRANCE DIAMETER** Both of the following sizes should be present[23]: Flicker-excavated (approximately circular): **6–7 cm** Pileated Woodpecker-excavated (usually oval, height x width): **11–12 x 9 cm** **CHAMBER DIMENSIONS** *For excavated cavities, chamber dimensions are indicated by entrance diameter*[19] **Cavity depth:** (20)[24] **27–35 cm ?** **Cavity diameter: 15–20 cm ?** **CAVITY HEIGHT** (above ground) **>(2) 5 m ?** ***Special Requirement:*** (bats - maternity roosts): **>10 m** ***Special Requirements:*** **THICK, FIRM CAVITY WALLS** (bats, others ?): ? *tentatively included as critical, no data available* **CAVITY TEMPERATURE**[21] (bats, others ?): *as in Table 2-3*	*All features are* ***Special Requirements.*** **IMMEDIATE SURROUNDINGS** **Dense tree cover** (Wood Duck, Marten ?) **Unobstructed flight path to the cavity**[22] (bats, swallows) **Sparse vegetation at and below nest height** (House Wren) **PROXIMITY TO SPECIFIC FOREST STANDS** Stands with: **Deciduous vegetation with low cover of shrubs or tall herbs** (House Wren) **Abundant conifer seed** (Red Squirrel) **Moderate conifer canopy closure and abundant CWD**[25] (Marten) **PROXIMITY TO OPEN AREAS OR EDGE** ? *data on actual distances insufficient* **In or near open areas** (many species, including European Starling) **Near edges if forests are closed** (House Wren, Little Brown Myotis, other bats ?) **PROXIMITY TO WATER** **<100 m from open water** (reported distance for most nests of the six duck species) **Near water** (bats: *may not be critical* ?) **MAXIMUM DISTANCE FROM FOREST** (species ?): ? *no data on actual distances* **MINIMUM STAND SIZE** (Wood Duck, Northern Saw-whet Owl, Northern Pygmy-Owl, Big Brown Bat, Silver-haired Bat, other bats ?, squirrels, Marten): ? *data on actual sizes insufficient* **STAND CONNECTIVITY** **Travel corridors of trees or CWD** (Marten, squirrels): *as in Table 2-5*

TABLE 2-5 *WT-5: Very large natural cavities and hollow trees*

Function and wildlife species associated with WT-5	Tree species and Decay Classes in which WT-5 occurs most commonly	Critical features of WT-5	
		Cavity size, above-ground height, and microclimate	Tree location
FUNCTION **Reproduction/Resting:** Existing cavities for nesting, denning, or resting **WILDLIFE SPECIES** (*SBS, ESSF, and ICH zones*) ■ Vaux's Swift ■ Fisher (reproduction) ◪ Barred Owl ◪ Big Brown Bat ◪ Silver-haired Bat ◪ Western Long-eared Myotis ◪ Little Brown Myotis ◪ Northern Long-eared Myotis (*rare*) ◪ Long-legged Myotis ◪ Red Squirrel ◪ Marten ◪ Fisher (resting) ☐ Barrow's Goldeneye ☐ American Kestrel ☐ Great Horned Owl ☐ Pileated Woodpecker (roosting) ☐ Southern Red-backed Vole ☐ Bushy-tailed Woodrat ☐ Deer Mouse ?☐ Northern Flying Squirrel ☐ Yellow-pine Chipmunk ☐ Ermine ☐ Long-tailed Weasel ?☐ Least Weasel (*rare*) ☐ Black Bear	**TREE SPECIES** *SBS zone*: **Black cottonwood** **Douglas-fir** *ESSF zone*: **Subalpine fir ?** *ICH zone*: **Western redcedar** **Western hemlock** **Black cottonwood** **DECAY CLASSES** **2, 3, 4, 5, 6, 7**	***All figures are tentative - data are very scarce.*** **ENTRANCE DIAMETER** *Requirements*[26] *vary greatly with species and number of cavity occupants.* Some reported[27] diameters: Vaux's Swift nest cavities with side entrances (entrances excavated by Pileated Woodpeckers, height x width): 11 x 8 cm Barred Owl: ≥18 cm Vaux's Swift communal roosts with top entrances (n=2 trees): 29, 64 cm Bats: *Information is insufficient for WT-5, but entrance size requirements are likely the same in WT-3, 4, and 5 ?* **CHAMBER DIMENSIONS** Vaux's Swift: **Depth**[28] (reported means): from side entrance down to nest: **2.1 m** (from side entrance to cavity bottom: 3.6 m) from top entrance to nest/roost: ? (from top entrance to cavity bottom: ?) **Diameter:** **>**(20)[29] **28 cm ?** ? *information for other species is insufficient* **CAVITY ENTRANCE HEIGHT** (above ground) **>**(8) **12 m ?** ***Special Requirements:*** **THICK, FIRM CAVITY WALLS** (bats, others ?): ? *tentatively included as critical, no data available* **CAVITY TEMPERATURE**[21] (bats, others ?): *as in Table 2-3*	*All features are* ***Special Requirements.*** **IMMEDIATE SURROUNDINGS** **Dense multi-layered canopy** (Barred Owl ?, Marten ?, Fisher) **Unobstructed flight path to the cavity entrance**[22] (bats, Vaux's Swift) **PROXIMITY TO SPECIFIC FOREST STANDS** Stands with: **Sparse or patchy understory ?** (Barred Owl) **Abundant conifer seed** (Red Squirrel) **Moderate canopy closure and abundant CWD**[25] (especially Marten, also Fisher) **PROXIMITY TO FOREST EDGE** **Near edges if forests are closed** (Little Brown Myotis, other bats ?) **PROXIMITY TO WATER** **Near water** (bats ?, Vaux's Swift: *probably not critical if sufficient insect prey is available over terrestrial habitats* ?) **MINIMUM STAND SIZE** (Barred Owl, Big Brown Bat, Silver-haired Bat, other bats ?, Red Squirrel, Marten, Fisher): ? *data on actual sizes insufficient* **STAND CONNECTIVITY** **Travel corridors of trees or CWD** (Marten, Fisher, squirrels): required if the distance through a treeless area exceeds 100 m ? (shorter for squirrels ?). Treeless, CWD corridors of any length may be unsuitable for Northern Flying Squirrel ? Corridor width: ? *data insufficient*

TABLE 2-6 ***WT-6: Cracks, loose bark, or deeply furrowed bark***

Function and wildlife species associated with WT-6	Tree species and Decay Classes in which WT-6 occurs most commonly	Critical features of WT-6		
		Cavity size, above-ground height, and microclimate	Cavity orientation	Tree location
FUNCTION **Reproduction/Resting:** Existing cavities for nesting or resting **WILDLIFE SPECIES** (*SBS, ESSF, and ICH zones*) ■ Brown Creeper (Sh?) ◪ Big Brown Bat (resting) ◪ Silver-haired Bat (mainly resting) ◪ Western Long-eared Myotis (resting) ◪ Little Brown Myotis (resting) ◪ Northern Long-eared Myotis (*rare*) ◪ Long-legged Myotis □ Winter Wren	**TREE SPECIES** ? *data insufficient* Reported nest-use by Brown Creeper includes all major tree species that occur in the SBS, ESSF, and ICH zones, *except* subalpine fir, Engelmann spruce, and paper birch. **DECAY CLASSES** **3, 4, 5, 6, 7** *Less commonly:* 1, 2	*Data are very scarce.* **ENTRANCE DIAMETER** Brown Creeper (reported mean of shortest dimension)[20]: 2.8 cm **CHAMBER DIMENSIONS** Brown Creeper (reported means)[20]: Cavity diameter: side to side: 16.6 cm front to back: 7.1 cm direction unspecified: 7.8 cm Cavity depth: 5.4 cm **CAVITY HEIGHT** (above ground) Brown Creeper: >2.1 m ? *data insufficient for bats* ***Special Requirement:*** **CAVITY TEMPERATURE**[21] (bats, others ?): *as in Table 2-3*	*Data are very scarce.* **BOTTOM OR SIDE ENTRANCES** ***Special Requirement:*** **SOUTHWESTERN EXPOSURE** (Little Brown Myotis day roosts) *No data for other species*	*All features are* ***Special Requirements.*** **IMMEDIATE SURROUNDINGS** **Unobstructed flight path to the cavity entrance**[22] (bats) **PROXIMITY TO SPECIFIC FOREST STANDS** **Older, coniferous or mixed forest**[16] (Brown Creeper) **PROXIMITY TO FOREST EDGE** **Near edges if forests are closed** (Little Brown Myotis, other bats ?) **PROXIMITY TO WATER** **Near water** (bats: *may not be critical* ?) **MINIMUM STAND SIZE** (Brown Creeper, Big Brown Bat, Silver-haired Bat, other bats ?): ? *data on actual sizes insufficient* **STAND CONNECTIVITY** **Treed corridors or tree patches** (Brown Creeper, others ?): required for crossing treeless ? areas >500 m ? wide

TABLE 2-7 ***WT-7: Witches' brooms***[31]

Function and wildlife species associated with WT-7	Tree species and Decay Classes in which WT-7 occurs most commonly	Critical features of WT-7	
		Deformity size and height above ground	Tree location
FUNCTION **Reproduction/Resting:** Non-cavity sites (open or covered) for nesting or resting **WILDLIFE SPECIES** (*SBS, ESSF, and ICH zones*) ■ Northern Flying Squirrel (winter resting) ?■ or ◪ Marten (non-winter resting) ?■ Fisher (non-winter and mild-winter[32] resting) ◪ Merlin ◪ Great Horned Owl ◪ Long-eared Owl (L,S) (*rare*) ◪ Northern Flying Squirrel (non-winter) ?◪ Red Squirrel ☐ Common Goldeneye ☐ Barrow's Goldeneye ☐ Northern Goshawk ?☐ Barred Owl ☐ Great Gray Owl	**TREE SPECIES** (*SBS, ESSF, and ICH zones*) **All spruces** *Less commonly:* Subalpine fir Lodgepole pine **DECAY CLASSES** 2, 3	**DEFORMITY SIZE** ? *actual measurements are scarce* Northern Flying Squirrel (range, n=34)[33]: Horizontal diameter: 0.5–1.0 m **ABOVE-GROUND HEIGHT** ? *data insufficient* ***Special Requirement:*** **Within (neither above nor below) the canopy of the nest tree and surrounding trees** (Barred, Great Gray, and Long-eared Owls)	*All features are* ***Special Requirements.*** **IMMEDIATE SURROUNDINGS** **Dense multi-layered canopy** (Marten ?, Fisher) **Warm roost temperature** (especially Northern Flying Squirrel in winter) **PROXIMITY TO SPECIFIC FOREST STANDS** Stands with: **Abundant conifer seed** (Red Squirrel) **Moderate canopy closure and abundant CWD**[25] (especially Marten, also Fisher) **PROXIMITY TO OPEN AREAS** **In or near open areas** (Great Horned Owl) **MINIMUM STAND SIZE** (Red Squirrel, Northern Flying Squirrel, Marten, Fisher): ? *data on actual sizes insufficient* **STAND CONNECTIVITY** **Travel corridors of trees or CWD** (Marten, Fisher, squirrels): *as in Table 2-5*

TABLE 2-8 ***WT-8: Large branches, multiple leaders, or large-diameter broken tops***

Function and wildlife species associated with WT-8	Tree species and Decay Classes in which WT-8 occurs most commonly	Critical features of WT-8	
		Tree structure and size	Tree location
FUNCTION **Reproduction/Resting:** Supports for large open nest structures; other open nest and roost sites for large-bodied species **WILDLIFE SPECIES** (*SBS, ESSF, ICH zones*) ■ Great Blue Heron (L,S) (colonial nester)[14] ■ Osprey (L) ■ Bald Eagle ■ Northern Goshawk ■ Swainson's Hawk (L?,S) (*rare*) ■ Red-tailed Hawk ■ Great Gray Owl ◪ Great Horned Owl ◪ Northern Hawk Owl (H) ◪ Barred Owl ◪ Commor Raven ☐ Golden Eagle ☐ Merlin ?☐ Peregrine Falcon (*rare*) ☐ Long-eared Owl (L,S) (*rare*) ☐ Marten (resting)	**TREE SPECIES** (*SBS, ESSF, and ICH zones*) *Data are scarce for the ESSF and ICH zones.* **Black cottonwood** **Douglas-fir** *Somewhat less commonly:* Trembling aspen Lodgepole pine ? **DECAY CLASSES** **1, 2, 3, 4, 5, 6**	**STRUCTURE OF NEST SUPPORT OR ROOST BRANCHES** ***Most Commonly Reported:*** **Crotch between large branches and trunk** **Crotch between multiple leaders** **Top of broken-off tree** ***Special Requirements:*** (owls and falcons, which do not build nests): **Existing stick-nests** of other species, or **Large concave tops of broken-off trees** (especially herons and eagles): **Open crown structure** for easy nest or roost access **Horizontal branches** for roosting **DIMENSIONS OF NEST SUPPORT OR ROOST BRANCHES** **Branch size:** Red-tailed Hawk (reported mean, n=18 nests)[15]: 8.9 cm diameter Bald Eagle: stout roost branches needed (? *no data on actual sizes)* ? *no data for other wildlife species* **Size of broken top surface:** ? *no data* Nest-support size and branch arrangement must be suitable to support nests of the following sizes (ranges of reported means - *tentative*): Nest diameter: 68–140 cm Nest depth: 40–90 cm **HEIGHT OF NEST SUPPORT OR ROOST BRANCHES** (above ground): **Nest heights** (range of reported means): **9–32 m** ***Special Requirements:*** **At or near the top of the nest tree and above the crowns of surrounding trees**, providing an unobstructed view from the nest (Osprey, Bald Eagle, Swainson's Hawk ?, and Red-tailed Hawk) **Within (neither above nor below) the canopy of the nest tree or surrounding trees** (Barred, Great Gray, and Long-eared Owls) **Low within the nest tree crown or below it** (Northern Goshawk) ? *no information for roosts*	*All features are Special Requirements.* **IMMEDIATE SURROUNDINGS** **Dense canopy** (Northern Goshawk, Barred Owl ?) **Moderate (30–50% ?) canopy closure** (Bald Eagle ?, Great Gray Owl) **Open/semi-open canopy or low canopy height** (Osprey, Red-tailed Hawk ?, Northern Hawk Owl ?) **Unobstructed flight path to the nest** (Northern Goshawk) **PROXIMITY TO SPECIFIC FOREST STANDS** **Forest with sparse or patchy understory ?** (Northern Goshawk, Barred Owl) **PROXIMITY TO OPEN AREAS** **In or near open or sparsely treed areas with sparse or patchy shrub layers** (many species associated with WT-8) **PROXIMITY TO WATER** **≤120 m from open water** (reported distance for most nests of Great Blue Heron, Osprey, and Bald Eagle) **MINIMUM STAND SIZE** (for reproduction/resting) (Northern Goshawk, Barred Owl ?): 8–10 ha ?

TABLE 2-9 *WT-9: Arthropods in wood or under bark*

Function and wildlife species associated with WT-9	Tree species and Decay Classes in which WT-9 occurs most commonly	Critical features of WT-9		
		Abundant suitable prey	Above-ground height of infestation	Tree location
FUNCTION **Foraging:** Feeding substrates harbouring arthropod prey **WILDLIFE SPECIES** (*SBS, ESSF, and ICH zones*) ■ Hairy Woodpecker ■ Three-toed Woodpecker ■ Black-backed Woodpecker (winter)[36] ■ Pileated Woodpecker (winter) ◪ Downy Woodpecker (L?) ◪ Black-backed Woodpecker (non-winter) ◪ Pileated Woodpecker (non-winter) ☐ Yellow-bellied Sapsucker (L,N) (*rare*) ☐ Red-naped Sapsucker (S) ☐ Red-breasted Sapsucker ☐ Northern Flicker	**TREE SPECIES** (*SBS, ESSF, and ICH zones*) **Lodgepole pine** **Spruces** **Douglas-fir** **Subalpine fir ?** **Western redcedar ?** Temporary, local high prey densities can also occur in any other tree species. **DECAY CLASSES** **2, 3, 4, 5, 6, 7, 8**	***Reported Woodpecker Prey Species That Occur in North-Central British Columbia:*** **IN WOOD** ***Invading Sound Wood*** (may be inaccessible for Downy Woodpecker): **Carpenter ants** (*Camponotus* spp.) **Wood-boring beetles** flatheaded borers: e.g., *Chrysobothrys* spp. ? (Buprestidae) roundheaded borers: e.g., *Saperda calcarata* (Cerambycidae) sawyer beetles: *Monochamus* spp. ? (Cerambycidae) **Wood-boring caterpillars** e.g., aspen carpenterworm: *Acossus populi* ? (Cossidae) **Ambrosia beetles** ? ***Present in Rotted (especially Moist) Wood:*** Numerous potential prey species (*not reviewed*) **UNDER BARK** ***Invading Live Bark:*** **Bark beetles** (e.g., *Dendroctonus* and *Ips* spp.) **Wood-boring beetles** (as above) **Wood-boring caterpillars** (as above) **Weevils** (species ?) **Checkered beetles** (Cleridae [insect predators]) ***Present under Loose Bark:*** Numerous potential prey species (*not reviewed*) ***Special Requirements:*** **Carpenter ants** (a major prey of Pileated Woodpecker) **Bark beetles** (the main prey of Three-toed Woodpecker)	***Winter:*** **ABOVE SNOW LEVEL**	*All features are* ***Special Requirements.*** **PROXIMITY TO SPECIFIC FOREST STANDS** Stands with: **Multi-layered, relatively dense canopy and numerous large trees** (Pileated Woodpecker) **MINIMUM STAND SIZE** (for foraging) (Pileated Woodpecker): ? *no data* **MAXIMUM DISTANCE FROM FOREST** (all species ?): ? *no data on actual distances* *No other consistent patterns are apparent.* Presence of abundant suitable prey generally overrides any potential importance of foraging substrate location ?

TABLE 2-10 *WT-10: Open-structured trees in or adjacent to open areas*

Function and wildlife species associated with WT-10	Tree species and Decay Classes in which WT-10 occurs most commonly	Critical features of WT-10	
		Tree structure and perch height	Tree location
FUNCTION **Foraging:** Hunting perches providing an unobstructed view of the hunting habitat for visually oriented predators (also used for resting)	**TREE SPECIES** ? *data insufficient* *Often used by Bald Eagle:* Black cottonwood (also conifers)	**TREE STRUCTURE** **Open crown structure**, often resulting from dead or broken branches, dead or broken tops, or seasonally bare crowns. Species hunting from low perches may use dead branches below a dense crown. ***Special Requirement:*** **Stout horizontal branches at or near the top of the crown** (especially Bald Eagle)	**IMMEDIATE SURROUNDINGS** In or adjacent to: **Unforested areas, forest openings, or areas with a sparse tree layer** ***Special Requirement:*** **Absence of ground-obstructing shrub or herb layer** (especially diurnal raptors, Mountain Bluebird) **Areas with abundant prey:** Small vertebrates (most diurnal raptors and owls, Northern Shrike) Fish and/or waterfowl (Osprey, Bald Eagle, Belted Kingfisher) Insects (especially flycatchers and Mountain Bluebird)
WILDLIFE SPECIES *(SBS, ESSF, and ICH zones)* ■ American Kestrel ■ Great Horned Owl ■ Northern Hawk Owl (H) ■ Great Gray Owl ■ Olive-sided Flycatcher ◪ Bald Eagle ◪ Red-tailed Hawk ◪ Merlin ◪ Northern Pygmy-Owl ◪ Barred Owl ◪ Boreal Owl (H) ◪ Northern Saw-whet Owl ◪ Belted Kingfisher ◪ Western Kingbird (L,S) (*rare*) ◪ Eastern Kingbird (L) ◪ Mountain Bluebird ◪ Northern Shrike (L) ☐ Osprey (L) ☐ Swainson's Hawk (L?,S) (*rare*) ☐ Rough-legged Hawk ☐ Golden Eagle ?☐ Short-eared Owl	**DECAY CLASSES** **2, 3, 4, 5, 6** *Less commonly:* 1, 7, 8	**PERCH HEIGHT** Bald Eagle (range of reported mean heights of perch trees): 19.1–23.8 m ? *no data for other species* ***Special Requirement:*** **Low perches** (Great Gray Owl ?, Belted Kingfisher, Mountain Bluebird): ? *no data on actual heights*	**PROXIMITY TO SPECIFIC FOREST STANDS** ***Special Requirement:*** **Stands with moderate (30–50 % ?) canopy closure** (Bald Eagle, Great Gray Owl ?) **PROXIMITY TO WATER** ***Special Requirements:*** **Next to open water** (Bald Eagle [*when hunting aquatic prey*], Osprey, Belted Kingfisher) **Near water** (Olive-sided Flycatcher [*probably not critical where terrestrial habitats offer sufficient prey*], Eastern Kingbird)

Footnotes Providing Additional Information for Tables 2-1 to 2-10 (Literature cited in the footnotes is shown at the end of the User's Guide)

1 In tree species with soft wood, decay may not be necessary for Pileated Woodpeckers to excavate nest cavities (Harris 1983; Bull 1987).

2 Some indicators are reliable signs of internal decay, but decay may also be present without any indicators. Reliance on indicators could thus result in underestimating the number of WT-1 and WT-2 trees present. Local field research is needed to determine indicator power: % of trees **with** the indicator that indeed have internal decay, in relation to the % of trees **without** the indicator that also have internal decay (see, for example: Anderson and Schipper 1978; Hiratsuka and Loman 1984). The proportion of decayed trees that lack fungal fruiting bodies as a decay indicator can be high (M. Machmer, pers. comm., March 1999).

3 Although ■-marked species associated with WT-1 and WT-2 excavate a new nest cavity each year, they often re-use the same tree for this purpose. Species marked ◪ associated with these two Types also frequently re-use the same tree, either excavating a new cavity or using an existing one (often re-occupying their **own** old cavities, at least in the case of Northern Flicker). Trees with existing cavities can thus serve as WT-1 or 2 as well as WT-3 or 4.

4 In balsam poplar (*Populus balsamifera* ssp. *balsamifera*), *Phellinus tremulae* does not commonly produce fruiting bodies (Hiratsuka and Loman 1984). This may also apply to black cottonwood.

5 Information is insufficient for conifer species of other zones included in this report (western redcedar, western hemlock, and whitebark pine).

6 Cavities are not drilled through live sapwood, even if internal decay is present.

7 Although both live and dead trembling aspen are suitable for WT-1 users, dead trembling aspen are less valuable from a management standpoint because they tend to fall relatively soon after tree death.

8 The actual critical feature is diameter at cavity height, rather than diameter at breast height (dbh), but the former is not shown because data are very scarce.

9 Reported mean sizes are mainly for ponderosa pine, western larch, grand fir, western white pine, and black cottonwood, as well as *Pinus* and *Abies* spp. not occurring in British Columbia.

10 For example, Pileated Woodpecker nest sites in northeastern Oregon had mean stem densities of 2.4 large (≥50 cm dbh) live trees and 1.9 large dead trees per 0.1 ha (Bull 1987 [n=105 nest trees]). Mean canopy height was 29 m and mean canopy closure was 70%. Roost sites had a mean canopy closure of 62.5% (Bull et al. 1992 [n=123]). Mean basal areas around Pileated Woodpecker nest and roost trees reported in a number of studies ranged from 25 to 36 m^2/ha.

11 These plants, especially birch, are used for sap-feeding. Western hemlock seems to be important in the ICH zone, as was found in the Revelstoke area (M. Machmer, pers. comm., March 1999). Subalpine fir also appears to be important in some areas (K. Parker, pers. comm., March 1999). Sapsuckers also feed, to a lesser extent, on sap, cambium, and phloem tissue of many other tree species (including pine, Douglas-fir, spruce ?, and aspen). Conifers are important in early spring. Large-diameter willow stems are becoming scarce in (parts of ?) north-central British Columbia because of the widespread continual killing of willow stems by the introduced weevil *Cryptorhynchus lapathi* (D. Keisker, pers. obs.).

12 Hairy, Three-toed, and Black-backed Woodpeckers appear to nest often near forest openings, but data are scarce. In Missouri, the mean distance of five Hairy Woodpecker nests from the nearest canopy opening was 7.4 m (Brawn et al. 1984). In contrast, for 14 Pileated Woodpecker nests the mean distance was 79.3 m.

13 The association of Downy Woodpeckers with trees having softened outer wood (WT-2) versus trees with hard outer wood (WT-1) requires further study. Downy Woodpeckers have been observed to excavate through hard outer wood. However, the species is shown as a WT-2 user because of its strong affinity for dead sapwood even in trembling aspen, and because its ability to penetrate hard outer wood may be limited to trees or tree portions in which this hard outer layer is thin. Further study is also needed for Northern Flickers.

14 Nuthatches, chickadees, and, in some areas, Downy Woodpeckers appear to be the main species that excavate nest or roost cavities in Interior Douglas-fir. Other woodpeckers show only limited nesting use of Interior Douglas-fir.

15 The soft outer wood is usually ? still harder than the inner wood.

16 Further research is needed to identify the actual critical features that are provided by mature or old-growth forests. For Red-breasted Nuthatches and Brown Creepers, these features may include structural diversity of the tree layer and abundance of bark arthropods. Conifer seed supply may be an additional critical feature for Red-breasted Nuthatches.

17 In the SBS and probably also in the ICH zone, the majority of small cavities are old nest holes excavated by sapsuckers and Hairy and Three-toed Woodpeckers. In the ESSF zone, most small cavities were probably excavated by Three-toed Woodpeckers. The "range" of means shown (narrowed to a single value by rounding to the nearest centimetre) is based on nests of Red-naped Sapsuckers and Hairy Woodpeckers. Means for species with n<15 (Red-breasted

Nuthatch, Black-backed Woodpecker, and Tree Swallow using mainly Hairy Woodpecker nests) also round to 4 cm.

18 In the SBS zone (and probably also in the ICH ?), the very small existing holes used by chickadees are often old nest holes excavated by Downy Woodpeckers.

19 In excavated nest cavities, the entrance diameters shown are a fairly reliable indicator of suitable internal cavity dimensions. However, in the case of natural cavities, feeding excavations, and unfinished nest cavities, entrance diameter cannot be used to indicate internal cavity dimensions. Natural cavities and feeding excavations can usually be distinguished from nest holes by the irregular shape of their entrances. Unfinished nest cavities are often identifiable by the funnel-shaped narrowing of the entrance.

20 Bats have often been reported to prefer cavities in large-diameter trees that are live or at early decay stages. Thick, firm cavity walls have been suggested as the critical feature underlying this preference. They would provide good thermal insulation and protection from predators and would lessen the danger of tree breakage.

21 Cavity temperature is affected by tree location (vegetation density in the immediate surroundings and topographic location), cavity dimensions, entrance orientation, wall thickness, and the metabolic rate, number, and spacing of the occupants.

22 The preference of bats for uncluttered roost tree surroundings may also be related to increased solar exposure and the resulting warmer roosts.

23 Most large (WT-4) cavities represent nest or roost holes excavated by Northern Flickers or Pileated Woodpeckers, or natural cavities. The range of means shown for Flicker-excavated cavities is based on >300 Northern Flicker nests, 26 Bufflehead nests, and 41 European Starling nests in the "Cariboo Parklands" of British Columbia (Erskine and McLaren 1972; Peterson and Gauthier 1985). The range of means shown for Pileated Woodpecker-excavated cavities is based only on nests and roosts of the excavator species (Bull 1987 [n=50 nest trees]; Bull et al. 1992 [n=60 roost trees]). Available measurements for Pileated Woodpecker cavities actually occupied by secondary cavity users are scarce.

Flicker-excavated cavities are usually too small for: Wood Duck, Common Goldeneye, Barrow's Goldeneye, Hooded Merganser, Common Merganser, Northern Hawk Owl ?, and Marten ?. Use of Flicker-excavated cavities has been observed very frequently for: Bufflehead, Northern Saw-whet Owl, Northern Flicker (often re-uses its cavities), European Starling, Mountain Bluebird, and Tree Swallow. Common Mergansers may need cavity entrances larger than those excavated by Pileated Woodpeckers (Lumsden et al. 1986 [nest box study]).

24 Data may have included small (WT-3) cavities. This depth may not be suitable for all species associated with WT-4.

25 In the SBS biogeoclimatic zone during winter, Marten tended to use areas in the 20–60% coniferous canopy closure classes and areas with >200 m^3 CWD (>20 cm in diameter), including >100 m^3 hard CWD (Lofroth 1993). Fishers in the SBS zone preferred areas in the 20–60% coniferous canopy closure classes, significantly so in winter, but also preferred areas with 20–40% deciduous canopy closure, significantly so in summer (Weir 1995). Fisher habitat use throughout the year is tied to presence of CWD, but required volumes of CWD appear to be lower than those reported for Marten.

26 It is not known whether species associated with WT-5 prefer the smallest entrances they can use, as most WT-3 and many WT-4 species do. If so, a range of entrance sizes must be available also for WT-5.

27 Vaux's Swift nests: Bull and Cooper (1991 [means, n=21]). The minimum entrance size used was 5.1 × 4.4 cm. Vaux's Swift nest cavities may have side or top entrances. No measurements are available for top entrances of nest trees. One chimney nest was in a 30 × 30 cm flue (Campbell et al. 1990b). Vaux's Swift communal roosts: Bull (1991). Barred Owl: Johnson (1987 [recommended entrance size for nest boxes]).

28 Data shown are from one study in Oregon (Bull and Cooper 1991 [n=19 nests]) where Vaux's Swifts attached their nests to the inside walls of hollow trees accessed through side entrances excavated by Pileated Woodpeckers. It is not clear which is critical: both the distance of the nest below the entrance hole and the height of the nest above the cavity bottom, or only the former. Data are therefore provided for both. Nests or roosts accessed from top entrances (i.e., through a broken-off tree top exposing the hollow core) may need to be deeper down than those in cavities with side entrances, because of greater exposure ? Furthermore, communal roosts (which may house several hundred swifts [Bull 1991]) probably need to be deeper than nest cavities. The depths of two communal roost cavities with top entrances were 6 and 9 m (Bull 1991). The roosting depth of the swifts within the 9-m deep cavity was estimated at 2–7 m below the top entrance.

29 Minimum reported nest-cavity diameter (Bull and Cooper 1991).

30 Entrance diameter: Raphael and White (1984 [n=10]). Chamber dimensions: Davis (1978 [n=5]), Raphael and White (1984 [n=10]).

31 In north-central British Columbia, witches' brooms represent growth deformities caused by fungal rusts (*Chrysomyxa arctostaphyli* on spruce, *Melampsorella caryophyllacearum* on subalpine fir) or dwarf mistletoe (*Arceuthobium americanum* on lodgepole pine). Lodgepole pine is also affected by needle cast fungus (*Elytroderma deformans*), but the resulting brooms are usually small and tuft-like. In addition, some trees, especially black spruce, produce physiological brooms that are not caused by pathogens.

32 During periods when temperatures are warmer than approximately -10°C (R.D. Weir, pers. comm.).

33 Mowrey and Zasada (1984).

34 Colonial species usually need several adjacent trees of the required Type.

35 Bednarz and Dinsmore (1982).

36 Black-backed and Pileated Woodpeckers seem to require WT-9 only when CWD is snow-covered and therefore unavailable as an alternative foraging substrate.

TABLE 3 *Cross-reference summarizing the associations of wildlife species (occurring in the SBS, northern ESSF, and northern ICH biogeoclimatic zones) with the 10 Types of Wildlife Trees (WTs) listed in Table 1 and described in Tables 2-1 to 2-10*

■ = *Species that seem to be restricted to the Type or that appear to strongly prefer it*

◪ = *Species that use alternative Types (or habitat elements other than Wildlife Trees) for the same function, without apparent strong preferences*

□ = *Species that have been reported to use the Type occasionally*

Wildlife species using Wildlife Trees	Types used for reproduction/resting								Types used for foraging	
	WT-1	WT-2	WT-3	WT-4	WT-5	WT-6	WT-7	WT-8	WT-9	WT-10
Birds										
Great Blue Heron								■		
Wood Duck				■						
Common Goldeneye				■			□			
Barrow's Goldeneye				■	□		□			
Bufflehead				■						
Hooded Merganser				■						
Common Merganser				◪						
Osprey								■		□
Bald Eagle								■		◪
Northern Goshawk							□	■		
Swainson's Hawk								■		□
Red-tailed Hawk								■		◪
Rough-legged Hawk										□
Golden Eagle								□		□
American Kestrel				■	□					■
Merlin				□			◪	□		◪
Peregrine Falcon								?□		
Great Horned Owl					□		◪	◪		■
Northern Hawk Owl				◪				◪		■
Northern Pygmy-Owl			◪	◪						◪
Barred Owl					◪		?□	◪		◪
Great Gray Owl							□	■		■
Long-eared Owl							◪	□		
Short-eared Owl										?□
Boreal Owl				■						◪
Northern Saw-whet Owl				■						◪
Vaux's Swift					■					
Belted Kingfisher										◪
Yellow-bellied Sapsucker	■								□	
Red-naped Sapsucker	■								□	
Red-breasted Sapsucker	■								□	
Downy Woodpecker		■							◪	
Hairy Woodpecker	■	□							■	
Three-toed Woodpecker	■	□							■	
Black-backed Woodpecker	■	□							■, ◪	
Northern Flicker	?□◪	◪		◪					□	
Pileated Woodpecker	■				□				■, ◪	
Olive-sided Flycatcher										■

TABLE 3 *Continued*

Wildlife species using Wildlife Trees	Types used for reproduction/resting								Types used for foraging	
	WT-1	WT-2	WT-3	WT-4	WT-5	WT-6	WT-7	WT-8	WT-9	WT-10
"Western Flycatcher" Complex				□						
Western Kingbird				□						◪
Eastern Kingbird										◪
Tree Swallow			◪	◪						
Violet-green Swallow			◪	◪						
Barn Swallow				□						
Common Raven								◪		
Black-capped Chickadee		?■◪	?□◪							
Mountain Chickadee		?◪□	?◪■	□						
Boreal Chickadee		◪	◪							
Chestnut-backed Chickadee		◪	◪							
Red-breasted Nuthatch		◪	◪							
White-breasted Nuthatch		□	■	□						
Brown Creeper			?□◪			■				
House Wren			◪	◪						
Winter Wren			□	□		□				
Mountain Bluebird			□	■						◪
Townsend's Solitaire				□						
Northern Shrike										◪
European Starling (introduced)			□	■						
House Finch				?□						
House Sparrow (introduced)			◪	◪						
Mammals										
Big Brown Bat				◪	◪	◪	◪			
Silver-haired Bat				◪	◪	◪	◪			
Hoary Bat					□					
Western Long-eared Myotis				◪	◪	◪	◪			
Little Brown Myotis				◪	◪	◪	◪			
Northern Long-eared Myotis				◪	◪	◪	◪			
Long-legged Myotis				◪	◪	◪	◪			
Southern Red-backed Vole				□	□	□				
Bushy-tailed Woodrat					□	□				
Deer Mouse				□	□	□				
Northern Flying Squirrel					◪	?□		■,◪		
Yellow-pine Chipmunk				□	□	□				
Red Squirrel					◪	◪		?◪		
Marten					◪	◪		?■◪	□	
Fisher						■,◪		?■		
Ermine					□	□				
Long-tailed Weasel					□	□				
Least Weasel				□	□	?□				
Black Bear						□				

TABLE 4 *The 79 vertebrate species that are associated with Wildlife Trees and have been recorded, or potentially occur, in the SBS, northern ESSF, and northern ICH biogeoclimatic zones. Species occurrence in these zones is based mainly on the* Checklist of Cariboo Birds *(Roberts and Gebauer 1992), Volumes 1 to 3 of* The Birds of British Columbia *(Campbell et al. 1990a, 1990b, 1997), and consultation with wildlife experts. Nomenclature and species codes are consistent with Cannings and Harcombe (1990).*

Wildlife Tree use[1]	Status[2]	English name (restrictions in distribution)[3]	Scientific name	Species code
Birds (60 species)				
●	Blue	**Great Blue Heron** (L,S)	*Ardea herodias*	B-GBHE
●	rare	**Wood Duck** (L,S)	*Aix sponsa*	B-WODU
●		**Common Goldeneye**	*Bucephala clangula*	B-COGO
●		**Barrow's Goldeneye**	*Bucephala islandica*	B-BAGO
●		**Bufflehead** (L)	*Bucephala albeola*	B-BUFF
●		**Hooded Merganser** (L)	*Lophodytes cucullatus*	B-HOME
●		**Common Merganser** (L)	*Mergus merganser*	B-COME
●		**Osprey** (L)	*Pandion haliaetus*	B-OSPR
●		**Bald Eagle**	*Haliaeetus leucocephalus*	B-BAEA
●		**Northern Goshawk**	*Accipiter gentilis*	B-NOGO
●	Red, rare	**Swainson's Hawk** (L?,S)	*Buteo swainsoni*	B-SWHA
●		**Red-tailed Hawk**	*Buteo jamaicensis*	B-RTHA
○		Rough-legged Hawk	*Buteo lagopus*	B-RLHA
○		Golden Eagle	*Aquila chrysaetos*	B-GOEA
●		**American Kestrel**	*Falco sparverius*	B-AMKE
●		**Merlin**	*Falco columbarius*	B-MERL
?○	Red, rare	Peregrine Falcon	*Falco peregrinus anatum*	B-PEFA
●		**Great Horned Owl**	*Bubo virginianus*	B-GHOW
●		**Northern Hawk Owl** (H)	*Surnia ulula*	B-NHOW
●		**Northern Pygmy-Owl**	*Glaucidium gnoma*	B-NPOW
●		**Barred Owl**	*Strix varia*	B-BAOW
●		**Great Gray Owl**	*Strix nebulosa*	B-GGOW
●	rare	**Long-eared Owl** (L,S)	*Asio otus*	B-LEOW
?○	Blue	Short-eared Owl	*Asio flammeus*	B-SEOW
●		**Boreal Owl** (H)	*Aegolius funereus*	B-BOOW
●		**Northern Saw-whet Owl**	*Aegolius acadius*	B-NSWO
●		**Vaux's Swift**	*Chaetura vauxi*	B-VASW
●		**Belted Kingfisher**	*Ceryle alcyon*	B-BEKI
●	rare	**Yellow-bellied Sapsucker** (L,N)	*Sphyrapicus varius*	B-YBSA
●		**Red-naped Sapsucker** (S)	*Sphyrapicus nuchalis*	B-RNSA
●		**Red-breasted Sapsucker**	*Sphyrapicus ruber*	B-RBSA
●		**Downy Woodpecker** (L?)	*Picoides pubescens*	B-DOWO
●		**Hairy Woodpecker**	*Picoides villosus*	B-HAWO
●		**Three-toed Woodpecker**	*Picoides tridactylus*	B-TTWO
●		**Black-backed Woodpecker**	*Picoides arcticus*	B-BBWO
●		**Northern Flicker**	*Colaptes auratus*	B-NOFL
●		**Pileated Woodpecker**	*Dryocopus pileatus*	B-PIWO
●		**Olive-sided Flycatcher**	*Contopus borealis*	B-OSFL
○	rare	"Western Flycatcher" Complex[4] (Sh?)	*Empidonax* spp.	B-WEFL
●	rare	**Western Kingbird** (L,S)	*Tyrannus verticalis*	B-WEKI
●		**Eastern Kingbird** (L)	*Tyrannus tyrannus*	B-EAKI
●		**Tree Swallow** (L)	*Tachycineta bicolor*	B-TRSW
●		**Violet-green Swallow**	*Tachycineta thalassina*	B-VGSW
○		Barn Swallow	*Hirundo rustica*	B-BASW
●		**Common Raven**	*Corvus corax*	B-CORA
●		**Black-capped Chickadee**	*Parus atricapillus*	B-BCCH
●		**Mountain Chickadee**	*Parus gambeli*	B-MOCH
●		**Boreal Chickadee** (H)	*Parus hudsonicus*	B-BOCH

TABLE 4 *Continued*

Wildlife Tree use[1]	Status[2]	English name (restrictions in distribution)[3]	Scientific name	Species code
●	rare	**Chestnut-backed Chickadee** (Sh)	*Parus rufescens*	B-CBCH
●		**Red-breasted Nuthatch**	*Sitta canadensis*	B-RBNU
●	rare	**White-breasted Nuthatch** (L,S)	*Sitta carolinensis*	B-WBNU
●		**Brown Creeper** (Sh?)	*Certhia americana*	B-BRCR
●	rare	**House Wren** (L,S)	*Troglodytes aedon*	B-HOWR
❍		Winter Wren	*Troglodytes troglodytes*	B-WIWR
●		**Mountain Bluebird**	*Sialia currucoides*	B-MOBL
❍		Townsend's Solitaire	*Myadestes townsendi*	B-TOSO
●		**Northern Shrike** (L)	*Lanius excubitor*	B-NOSH
●	introduced	**European Starling**	*Sturnus vulgaris*	B-EUST
?❍		House Finch (L?,S)	*Carpodacus mexicanus*	B-HOFI
●	introduced	**House Sparrow**	*Passer domesticus*	B-HOSP
Mammals (19 species)				
●		**Big Brown Bat**	*Eptesicus fuscus*	M-EPFU
●		**Silver-haired Bat**	*Lasionycteris noctivagans*	M-LANO
❍	rare	Hoary Bat	*Lasiurus cinereus*	M-LACI
●		**Western Long-eared Myotis**	*Myotis evotis*	M-MYEV
●		Little Brown Myotis	*Myotis lucifugus*	M-MYLU
●	Blue, rare	**Northern Long-eared Myotis**	*Myotis septentrionalis*	M-MYSE
●		**Long-legged Myotis**	*Myotis volans*	M-MYVO
❍		Southern Red-backed Vole	*Clethrionomys gapperi*	M-CLGA
❍		Bushy-tailed Woodrat	*Neotoma cinerea*	M-NECI
❍		Deer Mouse	*Peromyscus maniculatus*	M-PEMA
●		**Northern Flying Squirrel**	*Glaucomys sabrinus*	M-GLSA
❍		Yellow-pine Chipmunk	*Tamias amoenus*	M-TAAM
●		**Red Squirrel**	*Tamiasciurus hudsonicus*	M-TAHU
●		**Marten**	*Martes americana*	M-MAAM
●	Blue	**Fisher**	*Martes pennanti*	M-MAPE
❍		Ermine	*Mustela erminea*	M-MUER
❍		Long-tailed Weasel	*Mustela frenata*	M-MUFR
❍	rare	Least Weasel	*Mustela nivalis*	M-MUNI
❍		Black Bear	*Ursus americanus*	M-URAM

1 ● = Obligate or frequent Wildlife Tree user (61 species) (comprises all species marked ■ or ◪ in at least one Type in Tables 2-1 to 2-10)
❍ = Occasional Wildlife Tree user (18 species)

2 Red = Red-listed in British Columbia (BC Environment 1998)
Blue = Blue-listed in British Columbia (BC Environment 1998)
rare = rare in the SBS as well as in northern parts of the ESSF and ICH biogeoclimatic zones

3 See pages 16–17 for a legend of restrictions in species distribution.

4 Includes Pacific-slope Flycatcher (*Empidonax difficilis*) and Cordilleran Flycatcher (*E. occidentalis*). For further information on taxonomy and status of these species, see Volume 3 of *The Birds of British Columbia* (Campbell et al. 1997).

TABLE 5 *Research needs relevant to Wildlife Tree management. Descriptions of very important knowledge gaps are shown in bold print. Only the main topics are shown in this table. Other specific knowledge gaps are indicated by question marks throughout Tables 2-1 to 2-10. The identification of research needs is current only to 1994. Some of the listed topics are being addressed through research projects initiated since then.*

General topic	Description of research needs
SIZES OF FOREST FRAGMENTS AND HABITAT PATCHES	• **Required sizes of forest fragments used for reproduction/resting by Wildlife Tree users that require forest cover around their nest/den/roost trees.** Required forest fragment sizes used for foraging by Pileated Woodpeckers.
	• Required sizes of the patch of specific habitat immediately surrounding nest/den/roost trees of some Wildlife Tree users (*species shown in most of Tables 2-1 to 2-10, last column*)
TRAVEL CORRIDORS	• **Critical features and number/distribution of the travel corridors that are required by some Wildlife Tree users** (*species shown in Tables 2-2 to 2-7, last column*)
	• Distance between forest fragments beyond which travel corridors are required by the above Wildlife Tree users. At shorter distances, potential disadvantages of using corridors (e.g., longer total travel distance due to less direct route, territorial conflict) may outweigh the possible advantages of using corridors (e.g., thermal and snow interception cover, reduced predation risk).
HABITAT INTERSPERSION	• **Maximum distances between foraging habitat and reproductive or resting habitat of Wildlife Tree users**
DISTANCE TO OPEN AREAS OR TO FOREST	• Maximum distance of Wildlife Trees in forest to the nearest open (unforested) area, for wildlife species associated with open areas or forest edge (*species shown in Tables 2-1 to 2-8, last column*)
	• Maximum distance of Wildlife Trees located in open areas to the nearest forested area
WILDLIFE TREE HABITAT QUALITY OF DIFFERENT ECOSYSTEMS	• Total area required (contiguously or as separate patches) in different ecosystems (including seral ecosystems) to support specific population densities of Wildlife Tree users. This assessment of required area could replace estimation of required Wildlife Tree numbers for the more common Types of Wildlife Trees, especially for trees used as foraging substrates.
	• Ecologically most meaningful units (e.g., site series or smaller/larger units ?) for the above assessment of differences in Wildlife Tree habitat quality
REQUIRED NUMBERS OF WILDLIFE TREES	• Numbers of Wildlife Trees required to support specific population densities of Wildlife Tree users; especially important for the uncommon or rare Types of Wildlife Trees and for trees to be retained in open areas (e.g., hunting perches)
ROOSTING HABITAT REQUIREMENTS	• Do roost trees differ from nest trees, as documented by Bull et al. (1992) for Pileated Woodpeckers in Oregon?
	• Do features of roost tree location differ from those of nest tree location?
	• Do winter and summer roost trees and roost tree locations differ? An example would be the seasonal selection of roost trees according to topography (reflecting site temperature differences) that was observed for Pileated Woodpeckers in northeastern Oregon. *See also nest/roost temperature below.*

TABLE 5 *Continued*

General topic	Description of research needs
IMMEDIATE NEST/ROOST TREE SURROUNDINGS	• Requirements of secondary cavity users and open nesters regarding immediate nest/roost tree surroundings (*see Tables 2-3 to 2-8, last column*)
	• Effects of immediate surroundings and other factors (*see footnote 21 of Table 2*) on nest/roost cavity temperature. Should management aim at ensuring the availability of a diversity of thermal regimes?
HABITAT REQUIREMENTS OF INDIVIDUAL WILDLIFE SPECIES	• **Habitat requirements of the following obligate or frequent Wildlife Tree users that occur in the SBS, ESSF, or ICH zones of north-central B.C. are in particular need of local field study in that region: Hooded and Common Mergansers, Northern Hawk Owl, Northern Pygmy-Owl, Barred Owl, the local applicability of the large body of Scandinavian literature on the Boreal Owl, Vaux's Swift, Black-backed Woodpecker, Brown Creeper, Western and Northern Long-eared Myotis, Long-legged Myotis, Silver-haired Bat, maternal dens of Marten and the habitat surrounding the dens.**
	• Confirm which species of secondary cavity users require large cavities (WT-4, distinguish cavities made by Northern Flickers from those made by Pileated Woodpeckers) and which species can use smaller cavities (WT-3).
	• Capabilities/preferences of primary cavity excavators for outer wood hardness rated with the Knife Test scale (especially for Downy, Hairy, Three-toed, and Black-backed Woodpeckers and Northern Flickers). Is the thickness of hard outer wood critical for Downy Woodpeckers? *See footnote 13 of Table 2.*
PATTERNS OF WILDLIFE TREE USE IN DIFFERENT BIOGEOCLIMATIC ZONES	• **Information on Wildlife Tree use is very scarce for the ICH zone (moist, wet, and very wet subzones).** This zone is of particular interest because it is the only zone in Interior B.C. in which western redcedar and western hemlock are common, both of which appear to be important Wildlife Tree species. Patterns of Wildlife Tree use and ecology might therefore be different from other Interior zones.
ECOLOGY OF THE CRITICAL FEATURES OF EACH WILDLIFE TREE TYPE	• **Factors influencing development of the critical features, time frame of development, usable period, and frequency of occurrence in different ecosystems**
	• **Ecology, temporal dynamics, and landscape-level management of overmature deciduous stands that contain the critical wildlife habitat features described in this report**
	• **Ecology and habitat requirements of important prey species, especially carpenter ants and wood-boring beetles**
	• Power (i.e., strength of correlation) of field indicators of internal decay in north-central B.C. (*see footnote 2 of Table 2*). Indicator power can vary among tree species, decay species, sites?, and perhaps other factors?
	• Feasibility, cost, and benefits of artificial creation of critical features; especially relevant for rare Types such as WT-5 (Very Large Natural Cavities and Hollow Trees)

Table 6 Types of Coarse Woody Debris, arranged by function, that are required by wildlife species occurring in the SBS, northern ESSF, and northern ICH biogeoclimatic zones 38
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Table 10 Research needs relevant to Coarse Woody Debris management 55

TABLE 6 *Types of Coarse Woody Debris (CWD), arranged by function, that are required by wildlife species occurring in the SBS, northern ESSF, and northern ICH biogeoclimatic zones. Rocks, cutbanks, and tree bases are included in some of the Types. Only those configurations of features that appear to be required (i.e., marked ■ in Table 7) by at least one wildlife species are delineated as individual Types. Most Types are not mutually exclusive (i.e., a single piece of CWD can serve as more than one Type). In particular, the features of CWD-2, 4, and 6 often occur together in the same log or stack of CWD. Complete descriptions of each Type are provided in Tables 7-1 to 7-6.*

Main functions[1] of Coarse Woody Debris	Configurations of CWD features required by wildlife species occurring in the SBS, ESSF, and ICH zones	Main users
Reproduction/Resting[2]/ Escape: Concealed spaces	CWD-1: Large Concealed Spaces	Cats, mustelids, grouse, Snowshoe Hare, Bushy-tailed Woodrat, Porcupine, canids, Black Bear
	CWD-2: Small Concealed Spaces (or Soft Substrate Allowing Excavation of Such Spaces) at or below Ground Level beneath Hard Material	Amphibians, snakes, shrews, voles, squirrels, Deer Mouse, jumping mice, weasels
	CWD-3: Small Concealed Spaces above Ground Level	Winter Wren, Townsend's Solitaire, Northern Waterthrush, Pacific Treefrog, flycatchers, other passerines, Deer Mouse
Travel: a. Concealed runways	CWD-4: Long Concealed Spaces (or Soft Substrate Allowing Construction of Runways)	Long-toed Salamander, voles, Rubber Boa, shrews, Deer Mouse, squirrels, weasels
Travel: b. Exposed, raised travel lanes	CWD-5: Large or Elevated, Long Material Clear of Dense Vegetation	Squirrels, Marten
Foraging: Feeding substrates	CWD-6: Invertebrates in Wood, under Bark or Moss Cover, or in Litter/Humus Accumulated around CWD	Amphibians, woodpeckers, Winter Wren, shrews, Deer Mouse, Striped Skunk, bears

1 See attached "Addendum to Table 6" for a list of other functions of CWD.

2 Including hibernation, thermoregulation, and hygroregulation.

ADDENDUM TO TABLE 6

In addition to the main functions shown in Table 6, Coarse Woody Debris (CWD) serves a large number of other functions for many of the CWD users listed in Table 9 and for numerous other wildlife species. These other functions are not necessarily less important to the animals. However, they were not considered in the delineation of CWD Types, either because they do not require specific configurations of CWD features (i.e., any CWD can serve the function) or because they represent incidental uses of CWD, and for these reasons do not require specific management attention.

A (probably incomplete) list of such other functions reported for CWD is provided below because awareness of these numerous additional uses of CWD is useful when estimating the required overall abundance of CWD.

Other functions of Coarse Woody Debris (CWD)	Wildlife species or species groups associated with these functions
Uses Related to Reproduction/Resting	
Occasional bedding-down alongside large logs	Moose, Mule Deer
Occasional nesting next to logs or boulders	Ground-nesting birds, Heather Vole subnivean winter nests
Occasional use of stumps or logs as nest platforms	Common Nighthawk (esp. very decayed CWD), Canada Goose, Mallard
Occasional use of CWD floating or partly submerged in water, as nest platforms	Common Loon, grebes, American Coot, Black Tern
Use of partly submerged anchored CWD, or of floating CWD, as resting and preening sites	Waterfowl, Muskrat, River Otter, Mink
Uses Related to Foraging/Food	
Prey-plucking sites	Accipiter hawks
Use of stumps, elevated logs, upturned rootmasses, etc. as food-handling/lookout sites	Columbian Ground Squirrel, Yellow-pine Chipmunk, Red Squirrel, many birds (esp. ground feeders ?)
Shoreline logs extend foraging access into open water.	Solitary Sandpiper (also other shorebirds ?)
Use of partly submerged anchored CWD, or of floating CWD, as feeding sites	Muskrat, River Otter, Mink
Stumps classified as CWD (<1.3 m tall) may be used as low hunting perches.	Mountain Bluebird, Townsend's Solitaire, Northern Shrike, Barred Owl, Great Gray Owl, other owls ?, Belted Kingfisher, some flycatchers
Open-structured branches and roots of CWD may be used as perches for flycatching.	Probably all *Empidonax* flycatchers, other small species that flycatch occasionally
Gleaning for arthropods on CWD surfaces or in shallow bark irregularities	Many songbird and woodpecker species
Parts of recently fallen CWD may serve as food.	Beaver, Moose, Mule Deer
CWD supports the growth of wood-inhabiting fungi. In addition, water retention by CWD may enhance and prolong the fruiting of hypogeous fungi. Fungi, especially hypogeous species, are an important food.	Shrews, rodents (including squirrels)
Other Uses	
Marking sites	Mustelids
Sunning sites	Reptiles
Soil exposed by uprooted trees, and dry, very decayed wood may be used as dusting sites.	Grouse species
Use of logs as display (drumming) sites	Ruffed Grouse
Use of logs extending across streams or small canyons as bridges	Deer Mouse, Northern Flying Squirrel, jumping mice, Bobcat, Marten, and probably many others

TABLES 7-1 to 7-6. Descriptions of each of the six Types of Coarse Woody Debris listed in Table 6. Types are described in terms of their critical features, reported values or forms of these critical features, overall function, associated wildlife species (occurring in the SBS, northern ESSF, and northern ICH biogeoclimatic zones), and their relationship to the Log Decomposition Classification. "Special Requirements" pertain to only some of the wildlife species associated with the Type. Descriptions of Types are based mainly on habitat research results compiled from the literature. Question marks indicate that further information or confirmation of local applicability is needed. Terms and symbols are explained on pages 13–17. Footnotes are shown after Table 7-6. All information presented is current only to 1995.

TABLE 7-1 *CWD-1: Large concealed spaces*

Function and wildlife species associated with CWD-1	Log Decomposition Classes in which CWD-1 occurs most commonly	Critical features of CWD-1: Space size, microclimate, and access	Critical features of CWD-1: Degree of concealment
FUNCTION **Reproduction/Resting[1]/Escape:** Concealed spaces (Also used as hunting sites by some species, especially Fisher, and for food caching by Marten and Bushy-tailed Woodrat)	**LOG DECOMPOSITION CLASSES** **1, 2, 3**	**SPACE SIZE** ? *data insufficient* **SPACE MICROCLIMATE** ? *data insufficient* (Influenced by a variety of factors, including space dimensions, substrate [e.g., wood, rock, or soil], depth below snow or ground, and CWD location [immediate surroundings and topographic location]) ***Special Requirements:*** **Availability of a variety of resting sites with different thermal properties** (Marten, others ?): May be critical for thermoregulation ? **Subnivean spaces associated with wood[3]** (Marten, Fisher ?, others ?) **Spaces excavated in soil[4]** (Black Bear): often under upturned rootmasses ? ***Special Requirement:*** **ACCESS POINTS TO SUBNIVEAN SPACES[5]** (Marten, Fisher, others ?): Structures that create a break in the snow surface (e.g., overlapping stacks of CWD, limbs of the CWD, or nearby small conifers with low branches)	**DEGREE OF CONCEALMENT** ? *no specific data (difficult to quantify)* ***Reported forms of concealment:*** **Spaces under elevated logs** (logs supported by their limbs, other CWD, or ground irregularities) **Hollow logs/stumps or ones with very large cavities** **Upturned rootmasses** **Slash piles** **Spaces under or within rock** (e.g., large spaces under or among boulders, and caves or crevices in rock outcrops or cliffs) **CWD or rock + additional cover** (e.g., branches [esp. foliated or snow-covered] of the CWD itself or of adjacent plants, or other CWD positioned to form a concealed space) **Subnivean spaces associated with CWD or rocks** **Spaces excavated in soil (associated with CWD, rock, or cutbanks)**

WILDLIFE SPECIES
(*SBS, ESSF, ICH zones*)

- ■ Cougar
- ?■ or ◪ Lynx
- ?■ or ◪ Bobcat
- ■ Fisher (cold-winter[2] resting)
- ◪ Blue Grouse (H)
- ◪ Ruffed Grouse
- ◪ Snowshoe Hare
- ◪ Bushy-tailed Woodrat
- ◪ Porcupine
- ◪ Red Fox
- ?◪ or ■ Wolverine
- ◪ River Otter
- ◪ Marten
- ◪ Striped Skunk
- ◪ Black Bear
- □ Mallard
- □ Harlequin Duck (*rare*)
- □ Hooded Merganser (L)
- □ Common Merganser (L)
- ?□ or ◪ Spruce Grouse (H?)
- □ American Dipper
- ?□ or ◪ Woodchuck
- ?□ or ◪ Coyote
- ?□ or ◪ Gray Wolf
- ?□ or ◪ Long-tailed Weasel
- ?□ or ◪ Mink
- □ Grizzly Bear

Critical features of CWD-1

Location of the CWD

All features are ***Special Requirements.***

IMMEDIATE SURROUNDINGS

Presence of Red Squirrel middens (Marten)
Free space in front of entrance ?? (Red Fox: natal dens)
Absence of roads or other sources of disturbance (most species)

TOPOGRAPHIC LOCATION

On a slope for drainage (most species, *may not be critical depending on slope position and soil type*)[e]
On south-facing slopes ? (Red Fox: natal dens)
Higher elevations (Blue Grouse)

PROXIMITY TO SPECIFIC FOREST STANDS

Stands with:
Deciduous trees (especially trembling aspen) and abundant shrubs (including fruit-producing species) (Ruffed Grouse)
Moderate canopy closure[f] (Marten, Fisher)
Conifers dominating ? (Lynx, Wolverine, Porcupine)
Dense low-shrub cover (Porcupine, River Otter, Striped Skunk)
Abundant prey[g] (carnivores)

PROXIMITY TO OPEN AREAS OR EDGE ? *no data on actual distances*

Reported general habitat descriptions:
Open areas interspersed with dense shrub thickets (Striped Skunk)
Forest interspersed with open areas (Red Fox)
Some shrubby open areas and forest edges (Blue Grouse [not necessarily shrubby], Ruffed Grouse)

PROXIMITY TO WATER

Near relatively large waterbodies containing fish (River Otter, natal dens: within 800 m ?)
Near water (*not critical* ?) (Marten, Cougar, Gray Wolf)

MINIMUM STAND SIZE

(Blue Grouse ?, Ruffed Grouse, Lynx, Bobcat, Marten, Fisher): ? *data on actual sizes insufficient*

STAND CONNECTIVITY

Travel corridors of trees or CWD
(Marten, Fisher, others ?): Critical for distances >100 m ? through treeless areas.
Corridor width: ? *data insufficient*

TABLE 7-2 ***CWD-2: Small concealed spaces (or soft substrate allowing excavation of such spaces) at or below ground level beneath hard material***

Function and wildlife species associated with CWD-2	Log Decomposition Classes in which CWD-2 occurs most commonly	Critical features of CWD-2: Extent of concealed spaces or soft material[9] for burrow excavation; access	Critical features of CWD-2: Space size and degree of concealment	Critical features of CWD-2: Microclimate of the concealed space
FUNCTION **Reproduction/Resting[1]/ Escape:** Concealed spaces (Also used for food caching by many small mammals)	**LOG DECOMPOSITION CLASSES** **1, 2, 3**	**EXTENT OF AREA CONCEALED BY HARD MATERIAL** ? *data insufficient* ***Special Requirements:*** **BELOW-GROUND DEPTH OF SPACES OR SOFT MATERIAL** (hibernating species, others ?): ? *data insufficient:* Shallow: **<20 cm** ? (e.g., Heather Vole) Deep: **20-90 cm** (Golden-mantled Ground Squirrel) **>70 cm** ? (e.g., Yellow-pine Chipmunk, winter) **PRESENCE OF EXISTING SPACES** (non-burrowing species: Long-toed Salamander, Pacific Treefrog ?, garter snakes, Vagrant Shrew, other shrews ?, birds) **ACCESS POINTS TO SUBNIVEAN SPACES** (Marten, weasels ?): *as in Table 7-1*	**SIZE AND DEGREE OF CONCEALMENT** Space size small enough for effective concealment: ? *no data* ***Reported forms of concealment:*** **Small spaces under CWD resting on the ground** (e.g., under logs, slabs, stumps, exposed roots, or upturned rootmasses) **Hollow logs/stumps or ones with cavities at or below ground level** (with relatively hard shell) **Loose bark on CWD resting on the ground** **Subnivean spaces associated with CWD** **Rock providing small concealed spaces** (e.g., spaces under or among rocks, or crevices in rock outcrops) **Burrows in soft material[9] under CWD or rock** **Any of the above may have additional cover of concealing vegetation** (e.g., branches of the CWD itself or of adjacent trees or shrubs, or tall grass).	(Influenced by a variety of factors, *see Table 7-1*) **THERMAL PROPERTIES** ***Special Requirements:*** **Thermally buffered, subterranean spaces** (for hibernation: amphibians, reptiles, Golden-mantled Ground Squirrel, Yellow-pine Chipmunk, jumping mice) **Diversity of thermal regimes** (Long-toed Salamander ?) **HUMIDITY** ***Special Requirements:*** **Dry** (Heather Vole, Deer Mouse ?, others ?) **Moist** (all amphibians, all shrews ?, others ?)

WILDLIFE SPECIES
(*SBS, ESSF, ICH zones*)

- ■ Long-toed Salamander (not for reproduction)
- ■ Western Garter Snake[10]
- ■ Common Garter Snake
- ■ Common Shrew
- ■ Pygmy Shrew
- ?■ or ◪ Dusky Shrew
- ?■ or ◪ Water Shrew
- ■ Vagrant Shrew
- ?■ or ◪ Southern Red-backed Vole
- ?■ or ◪ Long-tailed Vole
- ■ Heather Vole (summer nests)
- ?■ or ◪ Golden-mantled Ground Squirrel (H)
- ■ Yellow-pine Chipmunk

- ◪ Western Toad
- ◪ Pacific Treefrog (L?,S)
- ?◪ or ■ Rubber Boa (S) (*rare*)
- ◪ Meadow Vole
- ◪ Deer Mouse
- ◪ Red Squirrel[11]
- ◪ Meadow Jumping Mouse
- ◪ Western Jumping Mouse
- ◪ Ermine
- ◪ Long-tailed Weasel
- ◪ Least Weasel (*rare*)

- □ Winter Wren
- □ Townsend's Solitaire
- □ Hermit Thrush
- □ Dark-eyed Junco
- □ Bushy-tailed Woodrat

Additional species often use CWD-2 as hunting sites, especially Marten and Fisher

Critical features of CWD-2

Location of the CWD

All features are Special Requirements.

IMMEDIATE SURROUNDINGS

Dense herb or shrub layer (Long-tailed Vole, Yellow-pine Chipmunk, Ermine, Long-tailed Weasel ?, others ?)
Dense? low?-shrub layer especially of Ericaceae (and similar families and willows) (Heather Vole)
Relatively dry sites (Heather Vole, Deer Mouse ?)
Mesic sites (Southern Red-backed Vole, Long-tailed Vole ?)
Grassy sites (Meadow Vole, jumping mice)
Relatively moist sites (Common, Water, and Vagrant Shrews, jumping mice)
Rich soils with low acidity (*may not be critical* ?) (Vagrant Shrew)
Sites (e.g., CWD-6) providing invertebrate prey (all amphibian species, shrews)

TOPOGRAPHIC LOCATION

Higher elevation (Golden-mantled Ground Squirrel)

PROXIMITY TO SPECIFIC FOREST STANDS

Stands with abundant conifer seed (Red Squirrel)
Forest[12] ? (Southern Red-backed Vole)

PROXIMITY TO OPEN AREAS OR EDGE

In or near:
Open forests, forest edges, or unforested areas (Heather Vole ?, Golden-mantled Ground Squirrel, Yellow-pine Chipmunk, Ermine ?, Long-tailed and Least Weasels ?)
Meadows and wetlands ? (Long-tailed Vole, Meadow Vole, jumping mice)

PROXIMITY TO WATER

Near temporary or permanent, quiet water bodies with shallow edges (all amphibians)
Near open water or wetlands (Rubber Boa ?, garter snakes, Pygmy Shrew, Vagrant Shrew, Water Shrew [**adjacent** to water], Western Jumping Mouse ?)

MINIMUM STAND SIZE

(Red Squirrel, Southern Red-backed Vole, others ?): ? *data on actual sizes insufficient*

MAXIMUM DISTANCE FROM FOREST

(Red Squirrel, Southern Red-backed Vole, others ?): ? *no data on actual distances*

TABLE 7-3 ***CWD-3: Small concealed spaces above ground level***

Function and wildlife species associated with CWD-3	Log Decomposition Classes in which CWD-3 occurs most commonly	Critical features of CWD-3: Size and above-ground height of the concealed space and degree of concealment	Critical features of CWD-3: Location of the CWD
FUNCTION **Reproduction/Resting:** Concealed spaces **WILDLIFE SPECIES** (*SBS, ESSF, ICH zones*) ■ Winter Wren ■ Townsend's Solitaire[13] ?■ Northern Waterthrush ◪ Pacific Treefrog (L?,S) (thermo-, hygroregulation) ◪ Yellow-bellied Flycatcher (L,N) (*rare*) ◪ "Western Flycatcher" complex (Sh?) (*rare*) ◪ American Dipper ?◪ or ☐ Wilson's Warbler ?◪ or ☐ Song Sparrow (L?) ?◪ or ☐ Dark-eyed Junco ◪ Deer Mouse ☐ Mallard ☐ Harlequin Duck (*rare*) ☐ Hermit Thrush ☐ American Robin ☐ Many Wildlife Tree users[14]	**LOG DECOMPOSITION CLASSES** **1, 2, 3, 4?** (*Difficult to relate to the Log Decomposition Classes because CWD-3 pertains mainly to CWD other than logs.*)	**SPACE SIZE AND DEGREE OF CONCEALMENT** ? *data insufficient* ***Special Requirements:*** **Relatively deep** cavities (Winter Wren) **Shallow** depressions or ledges (Yellow-bellied Flycatcher, Wilson's Warbler, Song Sparrow, Dark-eyed Junco, others ?) **Heavy moss cover** (*may not be critical* ?) (Yellow-bellied Flycatcher) ***Reported nest sites:*** **Cavities, depressions, and ledges:** **in upturned rootmasses** **in cutbanks, cliffs, or large rocks** (usually concealed by overhanging vegetation or other material, sometimes associated with large exposed tree roots) **in stumps, logs, or among stacks of logs** **ABOVE-GROUND HEIGHT** **>0.8 m** ? *data insufficient*	*All features are* ***Special Requirements.*** **IMMEDIATE SURROUNDINGS** **Dense low-shrub cover** (Winter Wren ?, Northern Waterthrush, Wilson's Warbler, Song Sparrow) **PROXIMITY TO SPECIFIC FOREST STANDS** **Wetlands with trees or tall ? shrubs** (e.g., black spruce, willows) *or* **dry stands of deciduous or mixed deciduous/coniferous trees** (Yellow-bellied Flycatcher) **Along small water courses or in other moist shady areas with an open mid-stratum** ("Western Flycatcher" complex) **Forest with a dense, structurally diverse lower stratum**[15] (Winter Wren) **Relatively open coniferous ? forest** (Townsend's Solitaire) **Forest or stands of tall shrubs** (Northern Waterthrush) **PROXIMITY TO OPEN AREAS OR EDGE** **In unforested, sparsely treed, or forest-edge areas with dense low-shrub patches/bands** (Wilson's Warbler [esp. willows], Song Sparrow) **PROXIMITY TO WATER** **Near temporary or permanent, quiet water bodies with shallow edges** (Pacific Treefrog) **Adjacent to or overhanging a clear-water, turbulent stream** (American Dipper) **Adjacent to or overhanging** (Northern Waterthrush) **or near** (Song Sparrow) **standing or slow-moving water** **MINIMUM STAND SIZE** ? *no data on actual sizes* **MAXIMUM DISTANCE FROM FOREST** (Winter Wren, Townsend's Solitaire ?, others ?): ? *no data on actual distances* **STAND CONNECTIVITY** ? *no data*

TABLE 7-4 ***CWD-4: Long concealed spaces (or soft substrate allowing construction of runways)***

Function and wildlife species associated with CWD-4		Log Decomposition Classes in which CWD-4 occurs most commonly	Critical features of CWD-4		
			Length of the concealed space, orientation, and access	Degree of concealment	Microclimate of the concealed space
FUNCTION **Travel:** Concealed runways		**LOG DECOMPOSITION CLASSES** **1, 2, 3?, 4?** (4 only for excavated runways)	**LENGTH** *(length of individual CWD pieces may not be critical as long as there is continuity):* *? actual measurements insufficient*	**DEGREE OF CONCEALMENT** Space size small enough for effective concealment: *? no data*	**HUMIDITY** ***Special Requirement:*** **Moist** (Long-toed Salamander)
WILDLIFE SPECIES *(SBS, ESSF, ICH zones)*					
■ Long-toed Salamander[16] ■ Southern Red-backed Vole ?■ most CWD-4 spp. (early spring[17]) ◪ Rubber Boa (S) (*rare*) ◪ Common Shrew ◪ Pygmy Shrew ◪ Dusky Shrew ◪ Water Shrew ◪ Vagrant Shrew ◪ Long-tailed Vole ?◪ or ☐ Heather Vole ◪ Deer Mouse ?◪ or ☐ Northern Flying Squirrel (winter) ◪ Yellow-pine Chipmunk ◪ Red Squirrel (winter) ◪ Ermine ?◪ or ☐ Long-tailed Weasel ?◪ or ☐ Least Weasel (*rare*)	☐ Winter Wren ?☐ Song Sparrow (L?) ?☐ or ◪ Meadow Vole ☐ Meadow Jumping Mouse ☐ Western Jumping Mouse *Additional species often use CWD-4 as hunting sites, especially Marten and Fisher*		**ORIENTATION** **Positioned to form nearly continuous travel lanes** ***Special Requirement:*** **ACCESS POINTS TO SUBNIVEAN SPACES**[5] (Marten, weasels ?): *as in Table 7-1*	***Reported forms of concealment:*** **Under or alongside logs resting on or close to the ground, with or without additional cover** (e.g., branches of the CWD itself or of adjacent trees or shrubs, tall grass, other CWD, or snow) **Logs with heavy moss cover**[18] **Networks of passages in stacks of CWD or talus** **Runways excavated in soft material**[7] **in, under, or alongside logs**	

Critical features of CWD-4

Location of the CWD

All features are ***Special Requirements.***

IMMEDIATE SURROUNDINGS

Dense herb or shrub layer (Long-tailed Vole, others ?)
Dense? low?-shrub layer especially of Ericaceae (and similar families and willows) (Heather Vole)
Relatively dry sites (Heather Vole, Deer Mouse ?)
Mesic sites (Southern Red-backed Vole, Long-tailed Vole ?)
Grassy sites (Meadow Vole)
Relatively moist sites (Common, Water, and Vagrant Shrews)
Rich soils with low acidity (*may not be critical* ?) (Vagrant Shrew)
Sites providing invertebrate prey (e.g., CWD-6) (Long-toed Salamander, all shrews)

PROXIMITY TO SPECIFIC FOREST STANDS

Stands with abundant conifer seed (Red Squirrel)
Forest[12] ? (Southern Red-backed Vole)

PROXIMITY TO OPEN AREAS OR EDGE

In or near:
Open forests, forest edges, or unforested areas (Heather Vole ?, Yellow-pine Chipmunk, Ermine ?, Long-tailed and Least Weasels ?)
Meadows and wetlands ? (Long-tailed Vole, Meadow Vole)

PROXIMITY TO WATER

Near temporary or permanent, quiet water bodies with shallow edges (Long-toed Salamander)
Near open water or wetlands (Rubber Boa ?, Pygmy Shrew, Water Shrew [**adjacent** to water], Vagrant Shrew)

MAXIMUM DISTANCE FROM FOREST

(Red Squirrel, Southern Red-backed Vole, others ?): ? *no data on actual distances*

TABLE 7-5 *CWD-5: Large or elevated, long material clear of dense vegetation*

Function and wildlife species associated with CWD-5	Log Decomposition Classes in which CWD-5 occurs most commonly	Critical features of CWD-5		
		Log length and above-ground height of the log top	Orientation	Location of the CWD
FUNCTION **Travel**: Exposed, raised travel lanes **WILDLIFE SPECIES** (*SBS, ESSF, ICH zones*) ■ Red Squirrel (non-winter) ?◪ or ■ Northern Flying Squirrel ?◪ or ■ Yellow-pine Chipmunk ◪ Red Squirrel (winter) ◪ Marten ☐ Bushy-tailed Woodrat ?☐ Lynx ?☐ Bobcat ☐ Fisher ☐ Ermine ☐ Long-tailed Weasel ☐ Least Weasel (*rare*)	**LOG DECOMPOSITION CLASSES** **1, 2, 3?** (**3** only if large)	LENGTH (*length of individual logs is not critical as long as there is continuity*): ? *data insufficient* **ABOVE-GROUND HEIGHT** **Top of log above dense surrounding vegetation**	**POSITIONED TO FORM NEARLY CONTINUOUS TRAVEL LANES**	*All features are* ***Special Requirements.*** **IMMEDIATE SURROUNDINGS** **Some tree cover** (Northern Flying Squirrel, Red Squirrel, Marten: if travel distances are long) **PROXIMITY TO SPECIFIC FOREST STANDS** **Stands with abundant conifer seed** (Red Squirrel) **PROXIMITY TO OPEN AREAS OR EDGE** In or near: **Open forests, forest edges, or unforested areas** (Yellow-pine Chipmunk) **MAXIMUM DISTANCE FROM FOREST** (Squirrels, Marten): ? *no data on actual distances* STAND CONNECTIVITY ? *data insufficient*

TABLE 7-6 ***CWD-6: Invertebrates in wood, under bark or moss cover, or in litter/humus accumulated around CWD***

Function and wildlife species associated with CWD-6	Log Decomposition Classes in which CWD-6 occurs most commonly	Critical features of CWD-6	
		Abundant suitable prey	Position of prey within substrate and substrate condition
FUNCTION **Foraging:** Feeding substrates	**LOG DECOMPOSITION CLASSES** **1, 2, 3, 4, 5** (1 only for woodpeckers)	***Special Requirements:*** **Ants** (important prey of Northern Flicker, Pileated Woodpecker, bears) **Soft-bodied invertebrates, especially worms?** (important prey of Long-toed Salamanders) *See Table 2-9 for a list of woodpecker prey species.*	**POSITION OF PREY** ***Reported foraging sites:*** **Inside the wood** **Between wood and bark** **Between wood and moss cover** **In the litter or humus layer accumulated around CWD** **SUBSTRATE CONDITION** **Uncharred CWD?** (Burning can render CWD less suitable for invertebrates, thus reducing prey abundance.) ***Special Requirement:*** **CWD with soft decayed wood, loose bark, or moss cover** (amphibians, shrews, rodents)
WILDLIFE SPECIES *(SBS, ESSF, ICH zones)*			
■ Long-toed Salamander	☐ Western Toad ?☐ Western Garter Snake ?☐ Common Garter Snake ?☐ Spruce Grouse (H?) ?☐ Blue Grouse (H) ?☐ Ruffed Grouse ?☐ or ◪ Downy Woodpecker (L?) ?☐ or ◪ Hairy Woodpecker ?☐ or ◪ Three-toed Woodpecker ?☐ Steller's Jay ?☐ or ◪ House Wren (L,S) (*rare*) ?☐ or ◪ Veery (L) ?☐ Swainson's Thrush ?☐ or ◪ Hermit Thrush ?☐ Nashville Warbler (S) ?☐ or ◪ Northern Waterthrush ?☐ Chipping Sparrow ?☐ Fox Sparrow (H?) ?☐ Song Sparrow (L?)	?☐ Lincoln's Sparrow ?☐ White-throated Sparrow ?☐ Golden-crowned Sparrow (H) ?☐ White-crowned Sparrow ☐ Water Shrew ☐ Southern Red-backed Vole ?☐ Northern Flying Squirrel ☐ Yellow-pine Chipmunk ?☐ Red Squirrel ?☐ Wolverine ?☐ Marten ?☐ Fisher ☐ Ermine ☐ Long-tailed Weasel ☐ Least Weasel (*rare*) ?☐ Mink	
◪ Pacific Treefrog (L?,S) ◪ Black-backed Woodpecker ?◪ Northern Flicker ◪ Pileated Woodpecker ◪ Winter Wren ?◪ or ☐ Dark-eyed Junco ◪ Common Shrew ◪ Pygmy Shrew ◪ Dusky Shrew ◪ Vagrant Shrew ◪ Deer Mouse ◪ Striped Skunk ◪ Black Bear ◪ Grizzly Bear			

TABLE 7-6 *Continued*

Critical features of CWD-6

Location of the CWD

All features are ***Special Requirements.***

IMMEDIATE SURROUNDINGS

Relatively dry sites (*may not be critical*?) (Deer Mouse)
Relatively moist sites (Common and Vagrant Shrews)
Rich soils with low acidity (*may not be critical*?) (Vagrant Shrew)

PROXIMITY TO SPECIFIC FOREST STANDS

Stands with:
Multi-layered, relatively dense canopy and numerous large trees (Pileated Woodpecker)
Forest with a dense, structurally diverse lower stratum[15] (Winter Wren)

PROXIMITY TO OPEN AREAS OR EDGE

Proximity to forest from CWD in open areas: ? *no data*
General habitat: **Open areas interspersed with dense shrub thickets** (Striped Skunk)

PROXIMITY TO WATER

Near temporary or permanent, quiet water bodies with shallow edges (all amphibian species)
Near open water or wetlands (Pygmy Shrew, Water Shrew [**adjacent** to water], Vagrant Shrew)

MINIMUM STAND SIZE

(Pileated Woodpecker): ? *no data*

MAXIMUM DISTANCE FROM FOREST

(Woodpeckers, Winter Wren, others?): ? *no data on actual distances*

Footnotes Providing Additional Information for Tables 7-1 to 7-6 (Literature cited in the footnotes is shown at the end of the User's Guide)

1 Includes hibernation and thermo- and hygroregulation.

2 During periods when temperatures are colder than -20°C (local study [SBS zone]: Weir 1995).

3 For Marten, subnivean resting sites associated with wood (CWD or low cavities in or below standing trees) may be critical during periods of colder temperatures (mean observed air temperatures: -5.5°C, Buskirk et al. 1989). Fisher in the SBS biogeoclimatic zone used subnivean resting sites (all were CWD-associated) during periods when temperatures were colder than -20°C (Weir 1995).

4 Winter dens excavated into the ground appear to be critical for Black Bears in northern latitudes (e.g., Manitoba, Alberta). In more southern areas (e.g., Tennessee, Georgia) winter dens are often also found at or above ground level.

5 Marten use access points to enter subnivean resting sites or hunting areas.

6 Also not critical during dry seasons, but most species use CWD-1 for reproduction during spring, a potentially wet season.

7 In the SBS biogeoclimatic zone during winter, Marten tended to use areas in the 20–60% coniferous canopy closure classes (Lofroth 1993). Fishers in the SBS zone preferred areas in the 20–60% coniferous canopy closure classes, significantly so in winter, but also preferred areas with 20–40% deciduous canopy closure, significantly so in summer (Weir 1995).

8 Habitat of small mammal prey includes CWD-2, 4, 5, and 6. These Types are thus important also to the predators that rely on small mammals.

9 Soft material for burrowing often results from the presence of CWD: soft decaying wood, fine debris, and humus are generated by decaying CWD, and forest litter is trapped by CWD (i.e., CWD both facilitates burrow construction and acts as protective cover). Soft material also pertains to soft or sandy soils not related to presence of CWD (i.e., CWD serves only as protective cover).

10 Garter snakes often use non-woody substrates for CWD-2.

11 Red Squirrel middens are often associated with CWD (Gurnell 1984), although not necessarily CWD-2 (any other CWD located in coniferous forest may also be used ?). Apart from food caching, middens are used for resting/escape (especially in winter) and sometimes for reproduction.

12 Forest may be required because of reliance on hypogeous fungi.

13 Most nests of Townsend's Solitaire recorded in British Columbia were not actually associated with wood (Campbell et al. 1997). The most common nest sites (95% of 331 described sites) were cutbanks, sometimes sheltered by exposed tree roots and perhaps other CWD.

14 Many Wildlife Tree users occasionally nest or roost in cavities in stumps short enough (i.e., <1.3 m) to be considered CWD-3: ☐ Wood Duck (rare), ☐ Common Goldeneye, ☐ Barrow's Goldeneye, ☐ Bufflehead, ☐ Hooded Merganser, ☐ Common Merganser, ☐ American Kestrel, ?☐ or ◪ Northern Flicker, ☐ Tree Swallow, ☐ Violet-green Swallow, ☐ Black-capped Chickadee, ☐ Mountain Chickadee, ☐ Boreal Chickadee (rare ?), ☐ Chestnut-backed Chickadee (rare), ☐ Red-breasted Nuthatch, ☐ White-breasted Nuthatch (rare), ☐ Brown Creeper, ☐ House Wren (rare), ☐ Mountain Bluebird, ☐ European Starling (introduced), ☐ House Sparrow (introduced), ☐ Big Brown Bat, ☐ Silver-haired Bat, ☐ Western Long-eared Myotis, ☐ Little Brown Myotis, ☐ Long-legged Myotis, ?☐ or ◪ Southern Red-backed Vole, ☐ Bushy-tailed Woodrat, ☐ Yellow-pine Chipmunk, ?☐ Marten (subnivean), ☐ Ermine, ☐ Long-tailed Weasel, and ☐ Least Weasel (rare).

15 Lower-stratum diversity may be provided by shrubs, large CWD of various forms and at various stages of decomposition, and banks of creeks or ravines.

16 Long-toed Salamanders are not restricted to CWD during their spring migration.

17 When alternative cover (e.g., herb layer, leaved-out shrub layer, snow, or unfrozen duff) is sparse or absent.

18 In a local study (SBS zone), Long-toed Salamanders were frequently found in the tunnels formed between log, ground, and the moss-layer that extended over both (K. Ward and B. Chapman. 1995. Amphibians in clearcuts and forests in the Cariboo Forest Region. Unpubl. rep., B.C. Min. For., Williams Lake, B.C.).

TABLE 8 *Cross-reference summarizing the associations of wildlife species (occurring in the SBS, northern ESSF, and northern ICH biogeoclimatic zones) with the six Types of Coarse Woody Debris (CWD) listed in Table 6 and described in Tables 7-1 to 7-6*

■ = *Species that seem to be restricted to the Type or that appear to strongly prefer it*

◪ = *Species that use alternative Types (or habitat elements other than CWD, rocks, or cutbanks [see explanation of CWD on page 13]) for the same function, without apparent strong preferences*

□ = *Species that have been reported to use the Type occasionally*

	Types used for reproduction/resting			Types used for travel		Types used for foraging
Wildlife species using CWD	**CWD-1**	**CWD-2**	**CWD-3**	**CWD-4**	**CWD-5**	**CWD-6**
Amphibians						
Long-toed Salamander		■		■		■
Western Toad		◪				□
Pacific Treefrog		◪	◪			◪
Reptiles						
Rubber Boa		?◪ or ■		◪		
Western Garter Snake		■				?□
Common Garter Snake		■				?□
Birds						
Mallard	□		□			
Harlequin Duck	□		□			
Hooded Merganser	□		□			
Common Merganser	□		□			
Spruce Grouse	?□ or ◪					?□
Blue Grouse	◪					?□
Ruffed Grouse	◪					?□
Downy Woodpecker						?□ or ◪
Hairy Woodpecker						?□ or ◪
Three-toed Woodpecker						?□ or ◪
Black-backed Woodpecker						◪
Northern Flicker			?□ or ◪			?◪
Pileated Woodpecker						◪
Yellow-bellied Flycatcher			◪			
"Western Flycatcher" Complex			◪			
Steller's Jay						?□
House Wren			□			?□ or ◪
Winter Wren		□	■	□		◪
American Dipper	□		◪			
Townsend's Solitaire		□	■			
Veery						?□ or ◪
Swainson's Thrush						?□
Hermit Thrush		□	□			?□ or ◪
American Robin			□			
Nashville Warbler						?□
Northern Waterthrush			?■			?□ or ◪
Wilson's Warbler			?◪ or □			
Chipping Sparrow						?□
Fox Sparrow						?□
Song Sparrow			?◪ or □	?□		?□
Lincoln's Sparrow						?□
White-throated Sparrow						?□
Golden-crowned Sparrow						?□

TABLE 8 *Continued*

Wildlife species using CWD	Types used for reproduction/resting			Types used for travel		Types used for foraging
	CWD-1	CWD-2	CWD-3	CWD-4	CWD-5	CWD-6
White-crowned Sparrow						?□
Dark-eyed Junco		□	?◪ or □			?◪ or □
Additional Wildlife Tree Users[1]			□			
Mammals						
Common Shrew		■		◪		◪
Pygmy Shrew		■		◪		◪
Dusky Shrew		?■ or ◪		◪		◪
Water Shrew		?■ or ◪		◪		□
Vagrant Shrew		■		◪		◪
Snowshoe Hare	◪					
Southern Red-backed Vole		?■ or ◪	?□ or ◪	■		□
Long-tailed Vole		?■ or ◪		◪		
Meadow Vole		◪		?□ or ◪		
Heather Vole		■		?◪ or □		
Bushy-tailed Woodrat	◪	□	□		□	
Deer Mouse		◪	◪	◪		◪
Porcupine	◪					
Northern Flying Squirrel				?◪ or □	?◪ or ■	?□
Woodchuck	?□ or ◪					
Golden-mantled Ground Squirrel		?■ or ◪				
Yellow-pine Chipmunk		■	□	◪	?◪ or ■	□
Red Squirrel		◪		◪	■, ◪	?□
Meadow Jumping Mouse		◪		□		
Western Jumping Mouse		◪		□		
Coyote	?□ or ◪					
Gray Wolf	?□ or ◪					
Red Fox	◪					
Cougar	■					
Lynx	?■ or ◪				?□	
Bobcat	?■ or ◪				?□	
Wolverine	?◪ or ■					?□
River Otter	◪					
Marten	◪		?□		◪	?□
Fisher	■				□	?□
Striped Skunk	◪					◪
Ermine		◪	□	◪	□	□
Long-tailed Weasel	?□ or ◪	◪	□	?◪ or □	□	□
Least Weasel		◪	□	?◪ or □	□	□
Mink	?□ or ◪					?□
Black Bear	◪					◪
Grizzly Bear	□					◪
Additional Wildlife Tree Users[1]			□			

1 Many Wildlife Tree users occasionally nest or roost in cavities in stumps short enough (i.e., <1.3 m) to be considered CWD-3. See footnote 14 of Table 7 for a complete list of these species. Table 8 shows only those species individually that also use other Types of CWD.

TABLE 9 *The 78 vertebrate species[1] that use Coarse Woody Debris (CWD) for main[2] functions and have been recorded, or potentially occur, in the SBS, northern ESSF, and northern ICH biogeoclimatic zones. Species occurrence in these zones is based mainly on the* Checklist of Cariboo Birds *(Roberts and Gebauer 1992), Volumes 1 to 3 of* The Birds of British Columbia *(Campbell et al. 1990a, 1990b, 1997), and consultation with wildlife experts. Nomenclature and species codes are consistent with Cannings and Harcombe (1990).*

Use[3] of Coarse Woody Debris	Status[4]	English name (restrictions in distribution)[5]	Scientific name	Species code
Amphibians (3 species)				
●		**Long-toed Salamander**	*Ambystoma macrodactylum*	A-AMMA
●		**Western Toad**	*Bufo boreas*	A-BUBO
●		**Pacific Treefrog** (L?,S)	*Hyla regilla*	A-HYRE
Reptiles (3 species)				
●	Blue, rare	**Rubber Boa** (S)	*Charina bottae*	R-CHBO
●		**Western Garter Snake**	*Thamnophis elegans*	R-THEL
●		**Common Garter Snake**	*Thamnophis sirtalis*	R-THSI
Birds (35 species)				
○		Mallard	*Anas platyrhynchos*	B-MALL
○	rare	Harlequin Duck	*Histrionicus histrionicus*	B-HADU
○		Hooded Merganser (L)	*Lophodytes cucullatus*	B-HOME
○		Common Merganser (L)	*Mergus merganser*	B-COME
?○or●		Spruce Grouse (H?)	*Dendragapus canadensis*	B-SPGR
●		**Blue Grouse** (H)	*Dendragapus obscurus*	B-BLGR
●		**Ruffed Grouse**	*Bonasa umbellus*	B-RUGR
?○or●		Downy Woodpecker (L?)	*Picoides pubescens*	B-DOWO
?○or●		Hairy Woodpecker	*Picoides villosus*	B-HAWO
?○or●		Three-toed Woodpecker	*Picoides tridactylus*	B-TTWO
●		**Black-backed Woodpecker**	*Picoides arcticus*	B-BBWO
?●		**Northern Flicker**	*Colaptes auratus*	B-NOFL
●		**Pileated Woodpecker**	*Dryocopus pileatus*	B-PIWO
●	rare	**Yellow-bellied Flycatcher** (L,N)	*Empidonax flaviventris*	B-YBFL
●	rare	**"Western Flycatcher" Complex**[6] (Sh?)	*Empidonax* spp.	B-WEFL
?○		Steller's Jay	*Cyanocitta stelleri*	B-STJA
?○or●	rare	House Wren (L,S)	*Troglodytes aedon*	B-HOWR
●		**Winter Wren**	*Troglodytes troglodytes*	B-WIWR
?○or●		American Dipper	*Cinclus mexicanus*	B-AMDI
●		**Townsend's Solitaire**	*Myadestes townsendi*	B-TOSO
?○or●		Veery (L)	*Catharus fuscescens*	B-VEER
?○		Swainson's Thrush	*Catharus ustulatus*	B-SWTH
?○or●		Hermit Thrush	*Catharus guttatus*	B-HETH
○		American Robin	*Turdus migratorius*	B-AMRO
?○		Nashville Warbler (S)	*Vermivora ruficapilla*	B-NAWA
●		**Northern Waterthrush**	*Seiurus noveboracensis*	B-NOWA
?●		**Wilson's Warbler**	*Wilsonia pusilla*	B-WIWA
?○		Chipping Sparrow	*Spizella passerina*	B-CHSP
?○		Fox Sparrow (H?)	*Passerella iliaca*	B-FOSP
?●or○		**Song Sparrow** (L?)	*Melospiza melodia*	B-SOSP
?○		Lincoln's Sparrow	*Melospiza lincolnii*	B-LISP
?○		White-throated Sparrow	*Zonotrichia albicollis*	B-WTSP
○		Golden-crowned Sparrow (H)	*Zonotrichia atricapilla*	B-GCSP
?○		White-crowned Sparrow	*Zonotrichia leucophrys*	B-WCSP
●		**Dark-eyed Junco**	*Junco hyemalis*	B-DEJU

TABLE 9 *Continued*

Use[3] of Coarse Woody Debris	Status[4]	English name (restrictions in distribution)[5]	Scientific name	Species code
Mammals (37 species)				
●		**Common Shrew**	*Sorex cinereus*	M-SOCI
●		**Pygmy Shrew**	*Sorex hoyi*	M-SOHO
●		**Dusky Shrew**	*Sorex monticolus*	M-SOMO
●		**Water Shrew**	*Sorex palustris*	M-SOPA
●		**Vagrant Shrew**	*Sorex vagrans*	M-SOVA
●		**Snowshoe Hare**	*Lepus americanus*	M-LEAM
●		**Southern Red-backed Vole**	*Clethrionomys gapperi*	M-CLGA
●		**Long-tailed Vole**	*Microtus longicaudus*	M-MILO
●		**Meadow Vole**	*Microtus pennsylvanicus*	M-MIPE
●		**Heather Vole**	*Phenacomys intermedius*	M-PHIN
●		**Bushy-tailed Woodrat**	*Neotoma cinerea*	M-NECI
●		**Deer Mouse**	*Peromyscus maniculatus*	M-PEMA
●		**Porcupine**	*Erethizon dorsatum*	M-ERDO
●		**Northern Flying Squirrel**	*Glaucomys sabrinus*	M-GLSA
?❍or●		Woodchuck	*Marmota monax*	M-MAMO
●		**Golden-mantled Ground Squirrel** (H)	*Spermophilus lateralis*	M-SPLA
●		**Yellow-pine Chipmunk**	*Tamias amoenus*	M-TAAM
●		**Red Squirrel**	*Tamiasciurus hudsonicus*	M-TAHU
●		**Meadow Jumping Mouse**	*Zapus hudsonius*	M-ZAHU
●		**Western Jumping Mouse**	*Zapus princeps*	M-ZAPR
?❍or●		Coyote	*Canis latrans*	M-CALA
?❍or●		Gray Wolf	*Canis lupus*	M-CALU
●		**Red Fox**	*Vulpes vulpes*	M-VUVU
●		**Cougar**	*Felis concolor*	M-FECO
●		**Lynx**	*Lynx canadensis*	M-LYCA
●		**Bobcat**	*Lynx rufus*	M-LYRU
●	Blue	**Wolverine**	*Gulo gulo*	M-GUGU
●		**River Otter**	*Lontra canadensis*	M-LOCA
●		**Marten**	*Martes americana*	M-MAAM
●	Blue	**Fisher**	*Martes pennanti*	M-MAPE
●		**Striped Skunk**	*Mephitis mephitis*	M-MEME
●		**Ermine**	*Mustela erminea*	M-MUER
?●		**Long-tailed Weasel**	*Mustela frenata*	M-MUFR
●	rare	**Least Weasel**	*Mustela nivalis*	M-MUNI
?❍or●		Mink	*Mustela vison*	M-MUVI
●		**Black Bear**	*Ursus americanus*	M-URAM
●	Blue	**Grizzly Bear**	*Ursus arctos*	M-URAR

1 Many Wildlife Tree users occasionally nest or roost in cavities in stumps short enough (i.e., <1.3 m) to be considered CWD-3 (see footnote 14 of Table 7). These species are not shown here unless they also use other Types of CWD.

2 Additional species use Coarse Woody Debris for other functions (see Addendum to Table 6).

3 ● = Obligate or frequent user of Coarse Woody Debris (52 species including "?●or❍") (comprises all species marked ■ or ◪ in at least one Type in Tables 7-1 to 7-6)
❍ = Occasional user of Coarse Woody Debris (26 species including "?❍or●")

4 Blue = Blue-listed in British Columbia (BC Environment 1998)
rare = rare in the SBS as well as in northern parts of the ESSF and ICH biogeoclimatic zones

5 See page 16-17 for a legend of restrictions in species distribution.

6 Includes Pacific-slope Flycatcher (*Empidonax difficilis*) and Cordilleran Flycatcher (*E. occidentalis*). For further information on taxonomy and status of these species, see Volume 3 of *The Birds of British Columbia* (Campbell et al. 1997).

TABLE 10 *Research needs relevant to Coarse Woody Debris (CWD) management. Descriptions of very important knowledge gaps are shown in bold print. Only the main topics are shown in this table. Other specific knowledge gaps are indicated by question marks throughout Tables 7-1 to 7-6. The identification of research needs is current only to 1995. Some of the listed topics are being addressed through research projects initiated since then.*

General topic	Description of research needs
LEVELS OF CWD RECRUITMENT IN NATURAL AND IN MANAGED FORESTS	• **Natural abundance and distribution of each Type of CWD in different ecosystems, in stands at different successional stages, and in stands that have been subject to different natural disturbance regimes**
	• **Time frame of development and usable period of each CWD Type in each of the above stand types**
	• **Comparison of natural levels and time frames of CWD recruitment with those in managed forests, and comparison of different management practices that affect CWD recruitment (e.g., silviculture system, rotation length, stand tending practices, and timber harvest practices affecting slash generation/slash location).** Of special interest are CWD-1 (large concealed spaces) and perhaps CWD-3 (includes upturned rootmasses), which are most likely to become uncommon in managed forests.
	• **Effects of post-logging site preparation (especially broadcast burning and mechanical treatments common in the SBS, ESSF, and ICH zones) on CWD abundance and distribution, and specifically on the critical CWD features identified in Tables 7-1 to 7-6 (including CWD surroundings, microclimate, and invertebrate prey). If possible, comparison of actual use of treated and untreated CWD by the wildlife species associated with the various CWD Types.**
SIZES OF FOREST FRAGMENTS AND HABITAT PATCHES	• **For CWD users that need tree cover around CWD: Required sizes of forest stands in fragmented woodlands**
	• For CWD users that need specific habitat around CWD: Required sizes of these patches of specific habitat (*Species shown in Tables 7-1 to 7-6, last column: Immediate Surroundings*)
TRAVEL CORRIDORS	• **Critical features and number/distribution of the treed travel corridors that are required by some CWD users** (*Species shown in Tables 7-1, 7-3, 7-5, last column: Stand Connectivity*)
	• Distance between forest fragments beyond which treed travel corridors are required by the above CWD users
DISTANCE TO OPEN AREAS OR TO FOREST	• **For CWD users primarily associated with forest: Maximum distance of CWD used in open areas from nearest forested area**
	• For CWD users associated with open areas or forest/nonforest edge: maximum distance of CWD used in forest from nearest open (unforested) area (*Species shown in Tables 7-1 to 7-6, last column: Proximity to Open Areas or Edge*)
QUANTITATIVE DESCRIPTIONS OF THE CRITICAL FEATURES OF CWD	• Actual measurements of the dimensions, microclimate, and degree of concealment of CWD-associated spaces that are used by wildlife, and of the sizes of CWD used by wildlife. Statistical use/availability assessments revealing actual wildlife preferences regarding these critical features would be especially valuable.
HABITAT REQUIREMENTS OF INDIVIDUAL WILDLIFE SPECIES	• **Habitat requirements of the following obligate or frequent CWD users that occur in the SBS, ESSF, or ICH zones of north-central B.C. are in particular need of local field study in that region: Long-toed Salamander (microhabitat features), Rubber Boa, Yellow-bellied Flycatcher, Northern Waterthrush, Lynx, Bobcat, Marten** (*information needed for the three preceding species:* **maternal dens and their surrounding habitat**).

APPENDIX: Bibliography of the literature consulted to prepare the Habitat Summary Tables on Wildlife Trees and Coarse Woody Debris

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